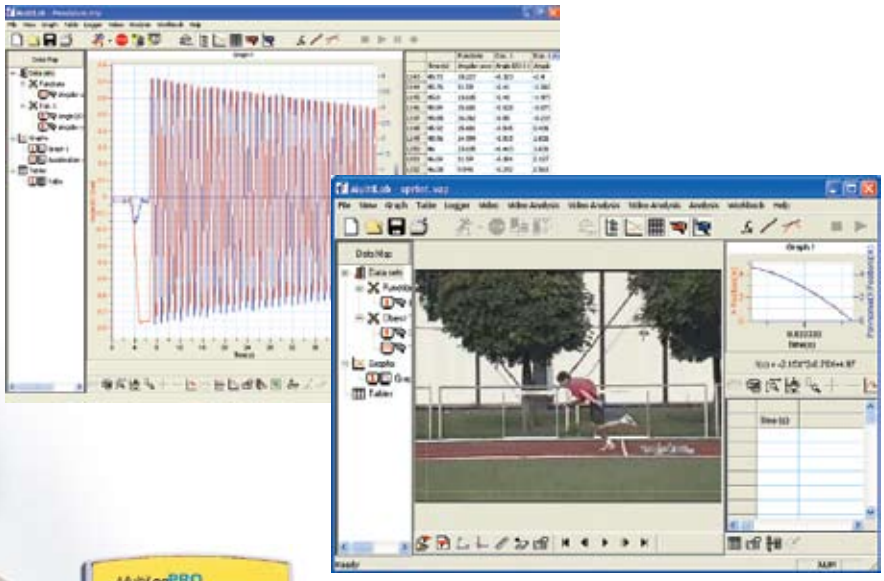
Integrating Student Computing & Science

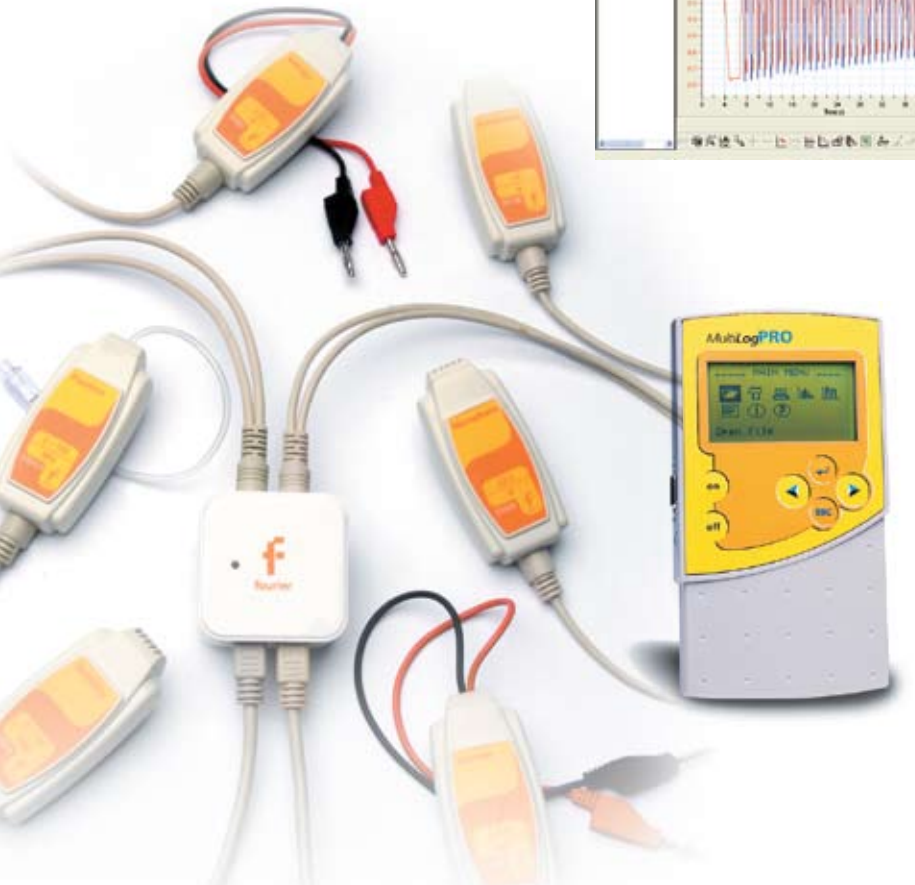
fourier

MultiLab

Powerful and simple to use analysis software with video and audio features

Supporting:
USB Link and MultiLogPRO Data Loggers





User Guide for PC

fourier

MultiLab PC User Guide

For USBLink and MultiLogPRO Data Loggers

Fifteenth Edition, First Print

September 2010

Released with MultiLab v1.5

fourier

© 2009 Fourier Systems Ltd. All rights reserved. Reproduction of this document in any manner without the prior written consent of Fourier Systems Ltd. is strictly forbidden.

Contents

What's New in MultiLab v1.5? 1

Introduction 1

USBLink Overview 1
MultiLogPRO Overview 2
HP SS410 Overview 2
User Guide Overview 3

Chapter 1 USBLink 4

1.1. General 4
1.1.1. USBLink System Contents 4
1.1.2. External Connections 4
1.1.3. Powering the USBLink 5
1.1.4. USBLink Memory 5
1.1.5. Input Modes 6
1. Auto ID 6
2. 8 Inputs 6
1.1.6. Quick-Start 6
1.1.7. Updating USBLink Firmware 7
1.1.8. Choose the Right Setup 7
1. Sampling Rate 7
2. Sampling Points 8
1.1.9. Programming Rules and Limitations 9
1. Sampling Points 9
2. Maximum Sampling Rate 9
3. Continuous Sampling 9
1.2. Sensor Calibration 10
1.2.1. Hardware Offset Calibration 10
1.2.2. USBLink Automatic Zero Calibration 10
1.2.3. pH Temperature Compensation 11
1.2.4. DO_2 Calibration 11
1.2.5. MultiLab Sensor Calibration 11
1.2.6. Factory Calibration (No Calibration Required) 11

Chapter 2 MultiLogPRO 12

2.1. General 12
2.1.1. MultiLogPRO System Contents 12
2.1.2. External Connections 13
2.1.3. Battery 14
2.1.4. AC/DC Adaptor 14
2.1.5. Automatic Shut-off 15
2.2. Standalone Operation 15
2.2.1. Front Panel Layout 15
2.2.2. Input Modes 16
1. Auto ID 16
2. 8 Inputs 16
2.2.3. Quick-Start 16
2.2.4. Working with the MultiLogPRO Menus 19
1. Turning MultiLogPRO On and Off 19
2. Main Menu Display 19
3. Menu Buttons 19
4. Menu Icons and Commands 20

2.2.5. Graphic Display 22
1. The Cursor 22
2. Zooming 22
2.2.6. Measuring Timing Events 22
1. Stopwatch 23
2. Time and Speed 24
3. Time, Speed and Acceleration 25
2.2.7. Select Sensors Manually 26
2.2.8. Load the Last Setup 27
2.2.9. Configure Your MultiLogPRO 27
1. Input Mode 27
2. Clear Memory 28
3. DO_2 Sensor Calibration 28
4. Screen Contrast 28
5. Connect to a Computer or to a TI Calculator 28
2.2.10. Internal Clock and Calendar 28
2.2.11. Clear the Memory 29
2.2.12. Choose the Right Setup 29
2.2.13. Programming Rules and Limitations 30
1. Sampling Points 30
2. Sampling Rate 31
3. Continuous Sampling 31
2.3. Sensor Calibration 32
2.3.1. Hardware Offset Calibration 32
2.3.2. MultiLogPRO Automatic Zero Calibration 32
2.3.3. pH Temperature Compensation 33
2.3.4. DO_2 Calibration 33
2.3.5. MultiLab Sensor Calibration 33
2.3.6. Factory Calibration (No Calibration Required) 33
Chapter 3 MultiLab Software 34
3.1. Installing the Software 34
3.1.1. System Requirements 34
1. Windows 34
2. Mac OS 34
3.1.2. Multiple Language Support 35
3.1.3. MultiLab Installation on Windows OS 35
3.1.4. MultiLab Installation on Mac OS 36
3.1.5. Installing USB Driver for USBLink 36
1. On MultiLab v1.4.22 and higher 36
2. On MultiLab v1.4.21 and older 36
3.1.6. Installing USB Driver for MultiLogPRO 37
1. On MultiLab v1.4.22 and higher 37
2. On MultiLab v1.4.21 and older 37
3.1.7. Uninstalling MultiLab 38
3.2. Overview 40
3.2.1. MultiLab On-screen Layout 40
3.2.2. MultiLab Window Layout 40
3.2.3. Working with Projects 41
3.3. Getting Started 41
3.3.1. Set up a Recording Session 41
1. Prepare the USBLink 41
2. Prepare the MultiLogPRO 41
3. Enable Video Recording 41

4. Setup the USBLink/MultiLogPRO 42
5. Start Recording 42
3.3.2. Data Recording Options 42
1. Single Measurement 42
2. Replace 42
3. Add 42
3.3.3. Manual Sampling 43
3.3.4. Online Video 43
1. Online Video 43
2. Recording 43
3. Replaying an Experiment 44
4. Video and Audio Properties 44
3.3.5. Download Data from the USBLink 44
3.3.6. Download Data from the MultiLogPRO 44
3.3.7. The Timer Module 45
1. Working with the Timer Module Wizard 45
2. Measuring Methods 46
3. Time Schemes and Calculations 48
3.3.8. Save Data 50
3.3.9. Open a File 50
3.3.10. Create a New Project 50
3.3.11. Import Data 50
3.3.12. Print 51
1. Print a Graph 51
2. Print a Table 52
3.4. Viewing the Data 53
3.4.1. Display Options 53
3.4.2. Graph Display 53
1. Split Graph View 54
2. The Cursor 54
3. Zooming 55
4. Manual scaling 55
5. The Stretch/Compress Axis tool 56
6. Panning 56
7. Edit the Graph 56
8. Format the Graph 57
9. Change the Graph's Units and its Number Format 57
10. Add Annotations to the Graph 58
11. Add a Graph to the Project 59
3.4.3. The Table Display 59
1. Editing Data Values 59
2. Editing the Table 59
3. Formatting the Table 60
4. Add a Table to the Project 60
3.4.4. Meters 61
3.4.5. Data Map 61
1. Control the Display with the Data Map 61
2. Understanding Data Map Icons 62
3.4.6. Export Data to Excel 63
1. Export File Settings 63
3.4.7. Copy the Graph as a Picture 63
3.5. Programming the Data Logger 64

3.5.1. Setup....64
1. Quick Setup....64
2. Defining Sensor Properties....65
3. Setting the Zero Point of a Sensor....66
4. Presetting the Display....67
5. Presetting the Graph's X-axis....67
6. Triggering....68
3.5.2. Start Recording....70
3.5.3. Stop Recording....70
3.5.4. Clear USBLink's Memory....70
3.5.5. Clear MultiLogPRO's Memory....70
3.5.6. Edit MultiLogPRO's Experiment Notes....70
3.5.7. Calibrating the Sensors....71
3.5.8. Define a Custom Sensor....71
3.5.9. Communication Setup....72
3.6. Analyzing the Data....74
3.6.1. Reading Data Point Coordinates....74
3.6.2. Reading the Difference between two Coordinate Values....74
3.6.3. Working with the Analysis Tools....74
3.6.4. Smoothing....74
3.6.5. Statistics....75
3.6.6. Most Common Analysis Functions....75
1. Linear Fit....75
2. Derivative....75
3. Integral....76
3.6.7. The Analysis Wizard....76
1. Using the Analysis Wizard....76
2. Curve Fit....76
3. Averaging....77
4. Functions....78
5. Editing a Function....79
3.6.8. Available Analysis Tools....79
1. Curve Fit....79
2. Averaging....80
3. Functions....80
3.6.9. Online Analysis....83
3.6.10. Manual Curve Fitting....85
3.7. Video Motion Analyzer....86
3.7.1. Overview....86
3.7.2. Getting Started....86
1. Video Motion Analyzer Basics....86
2. Saving a New Movie....87
3. Opening a Stored Movie....87
4. Saving a Video Motion Analyzer Project....87
5. Opening a Video Motion Analyzer Project....87
3.7.3. Capturing a New Movie....87
1. From a Device Attached to your Computer....87
2. From an External Source through a Video Board....88
3.7.4. Capturing Position and Time....89
1. Scaling....89
2. Set Coordinate System....90
3. Set Step....91

4. Mark the Video 91
5. Changing the Colors of the Marker and the Axes 94
3.7.5. Analyzing the Data 94
3.8. Workbook 95
3.8.1. Working with Workbook 95
3.8.2. Opening a Worksheet 95
3.8.3. Create Your Own Worksheet 96
1. Create an HTML Document with Word 96
2. Create a Configuration File 96
3.9. Special Tools 98
3.9.1. Predicting 98
3.9.2. The Timing Wizard 98
1. Overview 98
2. Working with the Timing Wizard 99
3. Measuring Methods 100
4. Time Schemes and Calculations 102
5. Tips on using the Timing Wizard 105
3.9.3. Crop Tool 106
1. To Trim all Data up to a Point 106
2. To Trim all Data Outside a Selected Range 106
3.9.4. Capture Tool 106
1. Preparing the Capture Table 107
2. Capturing Data 108
3. Displaying the Captured Data on the Graph 108
3.10. Toolbar Buttons 109
3.10.1. Main (Upper) Toolbar 109
3.10.2. Graph Toolbar 110
3.10.3. Table Toolbar 111
3.10.4. Video Motion Analyzer Toolbar 111
3.10.5. Capture New Movie Toolbar 112
Chapter 4 Working with a TI Calculator 113
4.1. Overview 113
4.2. Installing the Software 113
4.3. Getting Started 113
1. Prepare MultiLogPRO 113
2. Run MultiLab on a TI Calculator 114
3. Setup MultiLogPRO 114
4. Start Recording 115
5. View the Data 116
6. Downloading Data 116
4.4. The Graph Display 116
1. The Cursor 116
2. Zooming 116
3. Rescaling 117
4. Auto Scaling 117
5. X – Axis Scaling 118
6. Y – Axis Scaling 118
7. Choosing the X–axis 119
4.5. Analyzing the Data 119
1. Applying an Analysis Tool 119
2. Curve Fit 120

3. User Curve Fit....121
4. Statistics....121
5. Integral....122
4.6. Data Collection Modes....123
1. Log Data....123
2. Time Graph....124
3. Events with Entry....124
4. Single Point....124
5. Selected Event....125
4.7. Conditioned Data Collection....125
1. To Enable Triggering....125
2. To Disable the Triggering Condition....126
4.8. Calibrating the Sensors....126
1. To Calibrate a Sensor....126
2. To Restore the Default Calibration Values....127
Chapter 5 Troubleshooting Guide....128
Chapter 6 Specifications....131
6.1. The USBLink Data Logger....131
6.2. The MultiLogPRO Data Logger....132
6.3. Supported Sensors....134
6.3.1. Supported Fourier Systems Sensors....134
6.3.2. Supported Vernier Sensors....135
6.3.3. Supported Data Harvest Sensors....137
6.4. Accessories....138
6.5. MultiLab Software (Windows and Mac OS)....139
6.6. MultiLab Software (TI-83 PLUS Calculator)....140
Appendix A: Figures....141
Appendix B: Adding a Code Resistor to a Custom Sensor....142
Index....143

What's New in MultiLab v1.5?

This edition of the MultiLab User Guide includes the following updates, which were released with v1.5 of the MultiLab software:

- Integrated support for HP StreamSmart 410 data streamer
- Support for French and German language interface

Previous Versions

MultiLab 1.4.22 – March 2010

- Updated installation procedure for the USBLink USB driver. Refer to 36 for more details.
- Updated FTDI USB driver for the MultiLogPRO, supporting Windows 7 as well as automatic driver installation on Windows operating systems. Refer to 37 for more details.
- Support for Latvian language interface.

Introduction

MultiLab is a comprehensive PC software program that supports the full range of Fourier Systems data loggers. It provides everything you need in order to collect data, display the data in graphs, meters and tables, analyze the data with sophisticated analysis tools and even view online or recorded video movies of the actual experiment.

MultiLab supports the following products:

- USBLink
- MultiLogPRO
- HP StreamSmart 410 data streamer (refer to separate user guide for this product)

MultiLab includes four displays: Graph, Table, Video, and a navigation display called the Data Map. You can view all four displays simultaneously or view any combination of the four.

Unique video and audio features allow students to view online or recorded movies. Using a Web cam, students can film their experiment process, while the experiment data is displayed in graph, or meter format. Students can participate in e-learning projects, since MultiLab allows them to produce complete multimedia lab reports with real-time, synchronized annotated graphs and video.

Another useful feature is the Workbook tool. This gives students a step-by-step preview of the Lab activity to be conducted, and then automatically configures the MultiLab program and sets up the data logger so that the student can begin collecting the data. You can open an existing Workbook or create a new one.

MultiLab also includes a Video Motion Analyzer module that enables you to capture position and time from video movies and analyze the data with MultiLab's analysis tools.

USBLink Overview

To enhance your student computing solutions, Fourier incorporates our science and math legacy into our latest offering - the USBLink. We are presenting this together with our broad curriculum, probeware and analysis software as a distinct science solution. USBLink is a powerful, yet simple probe interface providing the key for a science hands-on solution to accompany every student computer.

This simple plug-n-play unit is highly-functional with 4-input interface, connecting via USB to the computer, in addition to automatic sensor recognition, fast sampling rate and sample streaming of up to 10,000 samples per second. Users can connect to a large selection of probeware available from Fourier. Firmware update via the software is also possible.

Students using any Web camera, together with the USBLink and Fourier probes can create multimedia science projects combining video, sound, text and samples of any experiment activity. Complemented by the Fourier vast curriculum library, K-12 teachers and students can experiment in all subjects: Physics, Chemistry, Biology, Environmental Sciences and Math.

MultiLogPRO Overview

The MultiLogPRO is a powerful standalone 12-bit data logger with a clear LCD graphic display and a 128K internal memory. Recorded data is displayed in the form of graphs, tables, meters or digital displays, and can be analyzed with a number of pre-programmed analysis functions.

The MultiLogPRO's internal memory stores experiment notes and instructions for carrying out the experiment, which can be edited or expanded at any time. These features enable MultiLogPRO to function independently from a computer - a perfect solution for when there is a shortage of computers in the laboratory.

MultiLogPRO can record data from up to 8 sensors simultaneously; it is capable of recording at rates of up to 21,000 samples per second, and of collecting up to 100,000 samples in its internal memory.

MultiLogPRO is very easy to use because all its functions are broken down into 8 icon menus, and its four buttons can browse every menu and execute any of the commands. In addition, when a sensor is plugged in, the MultiLogPRO automatically recognizes the type of sensor, and will record the data with the appropriate units.

A rechargeable battery powers the data logger, which shuts off automatically after 15 minutes have passed since the time of the last data recording, since the time the last button was pressed, or since the time the last communication with the PC.

MultiLogPRO includes a built-in, easy to use, accurate Timer module that enables the measuring of several types of timing events.

Together with the TI–83 Plus calculator, MultiLogPRO becomes a complete portable, handheld data collection and analysis system.

The large variety of sensors with which MultiLogPRO is compatible makes the unit a true *digital Lab*, which can measure scientific phenomena from the fields of Physics, Chemistry, Biology and the environmental sciences.

HP SS410 Overview

Enhancing your student solutions, HP and Fourier Systems incorporates its science and math technology together with its broad curriculum, probeware and analysis software, into its latest offering - the SS410 data streamer. SS410 is a powerful, yet simple probe interface providing the key for a science hands-on solution to accompany every student computer.

This simple plug-n-play unit is highly-functional with 4-input interface, connecting via USB to the computer, in addition to automatic sensor recognition, fast sampling rate and sample streaming of up to 10,000 samples per second. Users can connect to a large selection of probeware available from Fourier. Firmware update via the software is also possible.

In addition, the SS410 also connects to the HP 39gs and 40gs Graphing Calculator. More information on this solution is available from HP and from the SS410 User Guide, included on the MultiLab software CD.

User Guide Overview

This manual is divided into seven chapters:

- **The Introduction** provides an overview of the MultiLab supported products.
- **Chapters 1 and 2** are dedicated to the USBLink and MultiLogPRO data loggers respectively. These chapters explain how the data loggers themselves operate, and describe how to connect sensors, configure the loggers, and for the MultiLogPRO, operate the LCD graphic display to take measurements when working offline.
- **Chapter 3** gives a comprehensive overview of the MultiLab for Windows and Mac OS software. Topics include: How to download data from the data logger to a PC, analyzing the data both graphically and mathematically, and using the MultiLab software to program the data logger when working online.
- **Chapter 4** guides you in operating the MultiLogPRO and TI–83 Plus system, how to setup MultiLogPRO via the TI calculator, how to download the data and how to analyze this data.
- **Chapter 5** contains a troubleshooting guide that gives answers to common questions.
- **Chapter 6** includes the specifications of the data logger systems.

Chapter 1
USBLink

The USBLink is a 4-input sensor interface, able to accept the full range of Fourier sensors as well as certain Vernier and Data Harvest sensors. It connects to and is powered by the PC via a mini USB cable and features data logging capabilities based on the MultiLogPRO data logger design. The USBLink doesn't have a LCD screen and doesn't require external AC power source or batteries. It is a sensor interface only, so doesn't require onboard memory.

Note: USBLink data logger is supported by MultiLab PC software running on Windows XP and higher.

This chapter will focus on the USBLink data collection device and includes sections on:

- How to set up USBLink
- How to connect USBLink to your PC
- How to connect sensor to the USBLink
- How to upgrade USBLink firmware

1.1.General

1.1.1. USBLink System Contents

The following items are included in your USBLink order:

- USBLink data logger
- Mini USB communication cable
- MultiLab software mini CD

1.1.2. External Connections

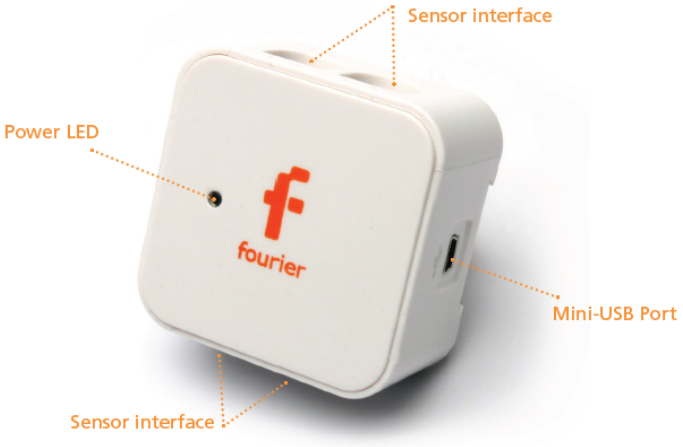


Figure 1: USBLink external connections

1. Sensor Inputs

Sensor input/output (I/O) sockets are marked on the USBLink casing as I/O-1, I/O-2, I/O-3 and I/O-4. These sockets are used to connect the sensors. Normally, all four sockets can be used simultaneously.

To connect a sensor to the USBLink, use one of the mini-din cables. Plug one end of the cable into the data logger - arrow facing up, and the other end into the sensor - arrow facing down.

If you are using one sensor only connect it to input 1. If you are using two sensors connect them to inputs 1 and 2, and so on.

In order to connect more than 4 sensors at a time, use Fourier splitter cables (Part Number DT011), which will enable the connection of up to 8 sensors simultaneously. When a splitter cable is connected, it must be connected to the socket in the correct numerical order (e.g. for 5 sensors, connect the splitter cable to I/O-1). One of the two splitter cables is marked with arrows - that is the main input (the lower I/O number), the second line is marked with the letter S (split) - indicating that it is the secondary input (the higher I/O number). Connect up to four input splitters to split the USBLink's inputs starting with I/O-4 (the splitters **must** be connected in order):

- I/O-4 splits into I/O-4 and I/O-8
- I/O-3 splits into I/O-3 and I/O-7
- I/O-2 splits into I/O-2 and I/O-6
- I/O-1 splits into I/O-1 and I/O-5

Note: Before connecting the mini-din cable to the data logger or the sensor sockets, make sure that the mini-din plug is correctly positioned in front of the socket. Connecting the cable in an awkward position might cause damage to the cable pins.

2. PC Mini USB communication socket

For USB communication between logger and PC, connect the USB Type B plug to the USBLink and the USB Type A plug to the PC.

1.1.3. Powering the USBLink

When connected to the PC via the mini USB cable, the USBLink draws power from the PC, via the USB port itself. No external AC power source is required. When the USBLink is connected to the USB port, the unit becomes operational and a green LED lights up on the logger casing. Certain sensors generally require external power supply when used with other loggers such as the MultiLogPRO. However, when connected to the USBLink, the external power is taken from the USB port as well.

Note: When powering the USBLink from a laptop running on battery, the laptop battery will drain at negligibly faster rate than normal.

1.1.4. USBLink Memory

The USBLink doesn't have onboard memory. When logging data, this data is displayed in the MultiLab software online, in real-time. The user must save this data in the software as it cannot then be downloaded from the USBLink later.

1.1.5. Input Modes

USBLink has two Input Modes. The default mode is **Auto ID** and the USBLink is in this mode when turned on for the first time.

When using more than four sensors, when using sensors from other vendors, or if you've defined your own sensor, you must unselect the Auto ID mode in the MultiLab software.

In the MultiLab main menu, go to **Logger > Auto ID** and disable Auto ID. To return to Auto ID mode, simply enable it again from the Logger menu.

USBLink saves the current mode selection and will open in that mode the next time you connect it to MultiLab.

A further explanation of the two Input modes is below.

1. Auto ID

Automatic sensor identification – just plug in the sensors and the USBLink prepares itself to collect data from these sensors.

While in this mode you can work with up to four sensors simultaneously.

2. 8 Inputs

When Auto ID is disabled, the USBLink is able to collect data from up to eight sensors simultaneously. Connect up to four input splitters (Part Number DT011) to multiply the USBLink's inputs starting with I/O-4 (the splitters **must** be connected in order):

- I/O-4 splits into I/O-4 and I/O-8
- I/O-3 splits into I/O-3 and I/O-7
- I/O-2 splits into I/O-2 and I/O-6
- I/O-1 splits into I/O-1 and I/O-5

In the splitter cable, one of the two wires is marked with arrows - that is the main input (the lower I/O number). The second wire is marked with the letter S (split) - indicating that it is the secondary input (the higher I/O number).

In 8 Inputs mode there is no automatic sensor identification. Select the sensors manually either from the Setup menu in the MultiLab software (see section 3.5.1 on page 64).

Use this mode if you want to work with more than four sensors or if you are using sensors from other vendors such as Vernier or Data Harvest.

1.1.6. Quick-Start

To run the USBLink logger follow these simple steps once the MultiLab software and USBLink USB driver have been installed.

1. Connect the mini USB cable to the USBLink USB port, and to the PC USB port.
2. Connect sensors to USBLink sensor interface, starting with I/O-1.
3. Launch MultiLab software. USBLink will be automatically detected.
4. Default Input Mode is Auto ID so sensors should also be automatically detected (unless you have connected sensors that must be manually selected).

5. Click **Run** in the MultiLab upper toolbar. Logger will start recording data and will display it in the MultiLab graph and table views. The default sample rate of 10 samples per second will be used.

6. Click **Stop** to stop the logger from recording data.

1.1.7. Updating USBLink Firmware

Use the MultiLab software to update the USBLink firmware whenever an updated version is made available.

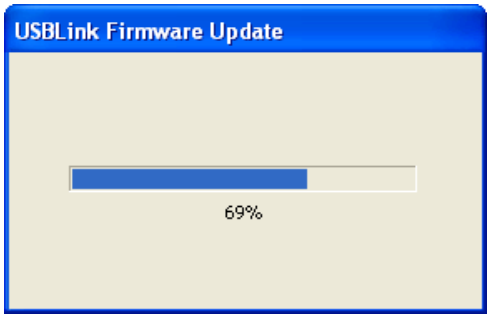
Follow these steps to update the USBLink firmware:

1. Download the latest firmware version from the Fourier Systems Download Center: http://www.fourier-sys.com/support_download.html

2. Save the firmware file to the MultiLab directory on your PC. The file must reside here before you launch MultiLab otherwise an error message will be displayed stating that the file wasn't found.

3. Connect the USBLink to the PC and launch MultiLab.

4. In the MultiLab main menu, go to **Logger > Firmware Update**. Follow the on-screen instructions to disconnect and connect the USBLink USB cable in order to launch the firmware update process.



5. Once the update process is complete, follow the on-screen instructions and disconnect and then connect the USBLink USB cable again. The firmware update process will then be complete and the firmware version will be displayed in the MultiLab status pane.

Note: If you disconnect the USBLink during the firmware update process, the previous firmware is still intact on the logger memory. You may continue the interrupted firmware updated by reconnecting the USBLink while MultiLab is open.

1.1.8. Choose the Right Setup

1. Sampling Rate

The sampling rate should be determined by the frequency of the phenomenon being sampled. If the phenomenon is periodic, sample at a rate of at least twice the expected frequency. For example, sound recordings should be sampled at the

highest sampling rate possible on the USBLink – 10,000/sec, but changes in room temperature can be measured at slower rates such as once per second or even slower, depending on the speed of the expected changes.

There is no such thing as over-sampling. For extremely smooth graphs, the sampling rate should be about 20 times the expected frequency.

Note: Sampling at a rate slower than the expected rate can cause *frequency aliasing*. In such a case, the graph will show a frequency much lower than expected. In Figure 2 below, the higher frequency sine wave was sampled at 1/3 of its frequency. Connecting the sampled points yielded a graph with a lower, incorrect frequency.

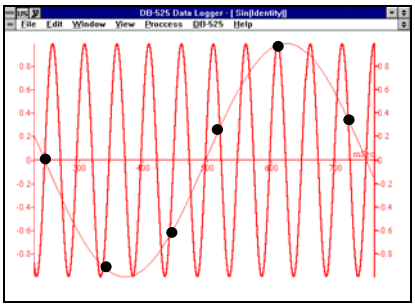


Figure 2: Frequency Aliasing

Manual sampling

Use this mode for:

- Recordings or measurements that are not related to time.
- Situations in which you have to stop recording data after each sample obtained, in order to change your location, or any other logging parameter.

Note: During the experiment *no changes* can be made to the USBLink's configuration.

2. Sampling Points

After you have chosen the sampling rate, choosing the number of points will determine the logging period: *Samples / Rate = Logging time*.

You can also choose the duration of an experiment first, and then calculate the number of samples: *Samples = Logging time × Rate*.

Continuous

In Continuous mode, USBLink will continue to record data for an unlimited period of time. The logger can continue logging indefinitely. Its only limitation is the size of the PC memory where the data is stored.

The data is displayed in a real-time graph.

To operate in Continuous mode, when configuring USBLink in MultiLab, select **Recording Time = Continuous**.

1.1.9. Programming Rules and Limitations

The following are some rules and limitations you must take into account when programming the USBLink, as the logger integrates all programming limitations automatically. USBLink will only allow the programming of settings that comply with the rules below.

1. Sampling Points

Increasing the number of active inputs limits the number of sampling points one can choose.

2. Maximum Sampling Rate

The maximum sampling rate depends on the number of sensors in use. See the table below:

Number of Sensors	Maximum Sampling Rate
1	10,000 samples per second
2	5,000 samples per second
3	3,333 samples per second
4	2,500 samples per second
5	2,000 samples per second
6	1.666 samples per second
7	1,428 samples per second
8	1,125 samples per second

3. Continuous Sampling

There is no limit to the sampling rate of the USBLink when running in Continuous sampling mode.

1.2.Sensor Calibration

In this chapter you will learn how to increase the USBLink system accuracy using calibration. Most of the sensors are linear, i.e. the output level of each sensor changes according to the equation:

$$Y = aX + b$$

Where:

Y - Output of the sensor (voltage level changing from 0 to 5V)

X - Sensor input

a - Sensor gain

b - Sensor offset

The calibration process allows us to control the offset, and in some cases even the gain, of a sensor. The USBLink system offers four types of calibration:

- Hardware offset calibration
- USBLink automatic zero calibration
- MultiLab Sensor calibration
- Factory calibration (no manual calibration required)

1.2.1. Hardware Offset Calibration

On some of the sensors there is a screw controlling the sensor offset. To calibrate the sensor, rotate this screw until the sensor shows the correct measured value (obtain the actual *correct value* from another source that is known to be accurate).

1.2.2. USBLink Automatic Zero Calibration

USBLink is able to automatically calibrate the sensor offset for all analog sensors accurately, quickly, and for every new experiment conducted.

The calibration method is very simple. Whenever you plug in a sensor, the data logger checks to see if the selected sensor measures a value within ± 2% of its *zero value*. If so, USBLink sets that value as zero.

To enable this feature, make sure that the sensors are at their zero values when you plug them in. To ensure the most accurate zero value, follow these instructions for the following sensors:

- Shorten the Voltage sensor plugs
- Leave the Current sensor plugs open
- Cover the Light, Photo Gate, and Microphone sensors
- Insert the pH sensor in a pH 7 solution
- Unload the Force Transducer
- Place the Accelerometer on a stationary surface
- Place the Temperature probes in ice water
- Place the Pressure sensor in a 1 ATM (1013 mb) chamber

1.2.3. pH Temperature Compensation

To compensate a pH sensor for temperature changes, plug the Temperature sensor into Input 1, and the pH sensor in Input 2. USBLink will then measure the compensated pH value.

1.2.4. DO_2 Calibration

When calibrating the DO_2 sensor for use with the USBLink, you should use the table below to obtain the relevant calibration value.

The default value is 8.26 mg/liter (zero altitude with no salinity).

		Salinity (ppt)							
		0	5	10	15	20	25	30	35
Altitude (ft)	0	8.26	8.03	7.81	7.59	7.38	7.17	6.97	6.77
	500	8.09	7.86	7.65	7.43	7.23	7.02	6.83	6.63
	1000	7.92	7.7	7.49	7.28	7.08	6.88	6.69	6.49
	1500	7.76	7.54	7.34	7.13	6.93	6.73	6.55	6.36
	2000	7.59	7.38	7.18	6.98	6.78	6.59	6.41	6.22
	2500	7.59	7.38	7.18	6.98	6.78	6.59	6.41	6.22
	3000	7.43	7.22	7.02	6.83	6.64	6.45	6.27	6.09
	3500	7.26	7.06	6.87	6.67	6.49	6.3	6.13	5.93

1.2.5. MultiLab Sensor Calibration

The sensors can also be calibrated using the **Calibrate Sensors** option in MultiLab's **Logger** menu. Please refer to section 3.5.7 for more information.

1.2.6. Factory Calibration (No Calibration Required)

All digital sensors that are essentially *timers* leave the factory fully calibrated, and do not suffer from any accuracy degradation. An example of such a sensor is the Sonic Ranger distance sensor, which measures the time passed from the transmission of a sound pulse to its echo reception.

Chapter 2
MultiLogPRO

This chapter will focus on the MultiLogPRO data collection device and includes sections on:

- How to operate the MultiLogPRO keypad
- How to set up MultiLogPRO
- How to connect MultiLogPRO to your PC

2.1. General

2.1.1. MultiLogPRO System Contents

The following picture indicates the items included in the basic MultiLogPRO kit you have ordered, together with the carrying case.

Figure 3: Contents of the MultiLogPRO system

1. The MultiLogPRO data logger
2. Sensors (see your package list)
3. Four sensor *mini-din* cables
4. USB and Serial Communication cables (see your package list)
5. Web camera (optional)
6. MultiLab software installation CD
7. AC-DC adaptor

2.1.2. External Connections

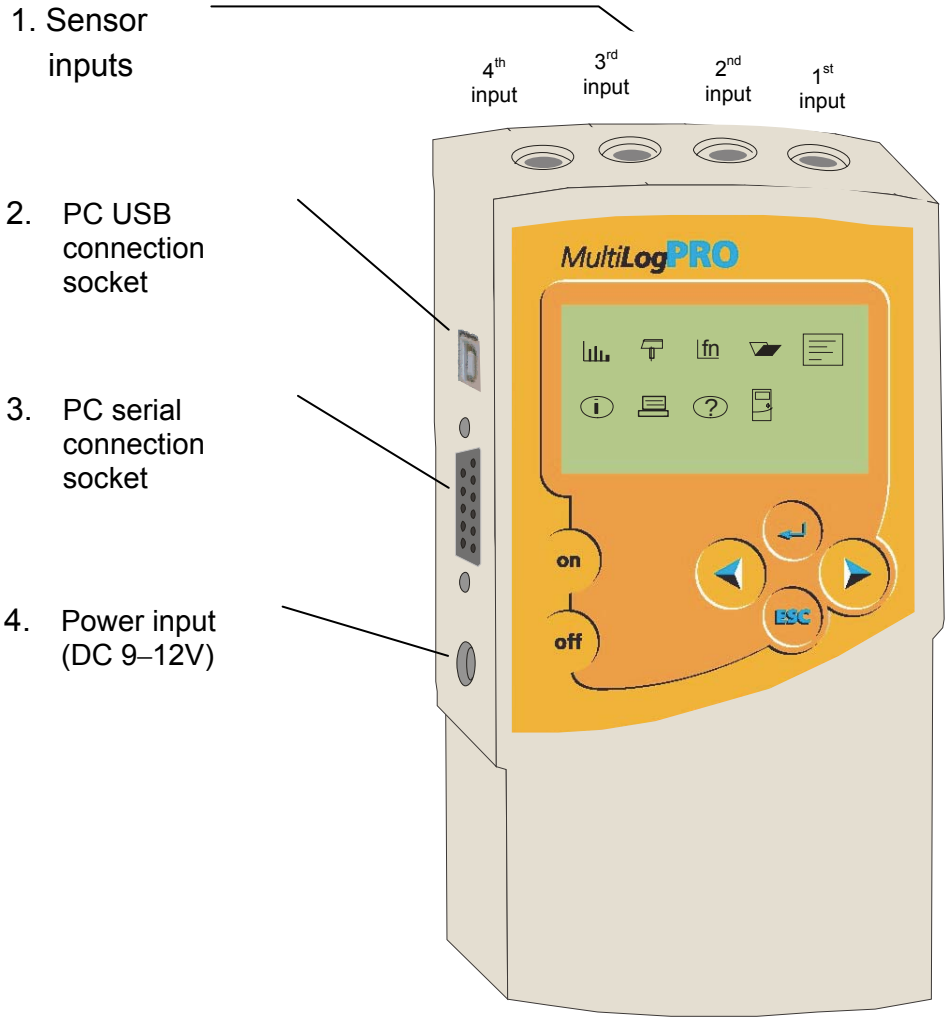


Figure 4: MultiLogPRO external connections

1. Sensor Inputs

Sensor input/output (I/O) sockets are marked on the MultiLogPRO casing as I/O-1, I/O-2, I/O-3 and I/O-4. These sockets are used to connect the sensors. Normally, all four sockets can be used simultaneously.

To connect a sensor to the MultiLogPRO use one of the mini-din cables. Plug one end of the cable into the data logger - arrow facing up, and the other end into the sensor - arrow facing down.

If you are using one sensor only connect it to input 1. If you are using two sensors connect them to inputs 1 and 2, and so on.

In order to connect more than 4 sensors at a time, use Fourier splitter cables (Part Number DT011), which will enable the connection of up to 8 sensors simultaneously. When a splitter cable is connected, it must be connected to the socket in the correct numerical order (e.g. for 5 sensors, connect the splitter cable to I/O-1). One of the two splitter cables is marked with arrows - that is the main input (the lower I/O number), the second line is marked with the letter S (split) - indicating that it is the

secondary input (the higher I/O number). Connect up to four input splitters to split the MultiLogPRO's inputs starting with I/O-4 (the splitters **must** be connected in order):

- I/O-4 splits into I/O-4 and I/O-8
- I/O-3 splits into I/O-3 and I/O-7
- I/O-2 splits into I/O-2 and I/O-6
- I/O-1 splits into I/O-1 and I/O-5

Note: Before connecting the mini-din cable to the data logger or the sensor sockets, make sure that the mini-din plug is correctly positioned in front of the socket. Connecting the cable in an awkward position might cause damage to the cable pins.

2. PC USB communication socket

For USB communication between logger and PC, connect the USB Type B plug to the MultiLogPRO and the USB Type A plug to the PC (see page 35 for USB driver installation).

3. PC serial communication socket

For Serial communication between logger and PC, connect the 9-pin Type D cable between this port and one of the computer's PC COM ports. At the back of the computer you will find a 9-pin Type D male socket. If your computer is using this port for the mouse, look for a 25-pin D shell male socket near the mouse. Use the RS-232 9 to 25-pin adaptor to connect the MultiLogPRO serial cable to the 25-pin port (the adaptor is included with the MultiLogPRO).

4. External DC power supply socket

Plug in an AC/DC 9-12V adaptor whenever you want to save battery power, or to charge the battery when necessary. Connecting external power to the MultiLogPRO automatically charges the internal battery. The adaptor should meet the required specifications (see section 2.1.4).

2.1.3. Battery

MultiLogPRO is equipped with a 7.2V NiCad rechargeable battery. Before you first start working with MultiLogPRO, charge the unit for 10 to 12 hours while it is turned off. Battery life is approximately 24 hours between charges.

If the data logger's main battery runs out, the internal 3V Lithium battery backs up the memory, so no data will be lost.

Note: Before storing the data logger make sure you have unplugged all the sensors and pressed the OFF key.

2.1.4. AC/DC Adaptor

- Output: Capacitor filtered 9 to 12 VDC, 400 mA
- Female plug, center Negative

2.1.5. Automatic Shut-off

MultiLogPRO shuts off automatically after 15 minutes have passed since the time of the last data recording, the time the last button was pressed, or the time the last communication was made with the PC.

2.2. Standalone Operation

One way to program the MultiLogPRO is to use its keypad and screen (the other way is to use the MultiLab software - see Chapter 3). The keypad allows us to set all the parameters for data collection, while the LCD screen displays the setting values.

2.2.1. Front Panel Layout

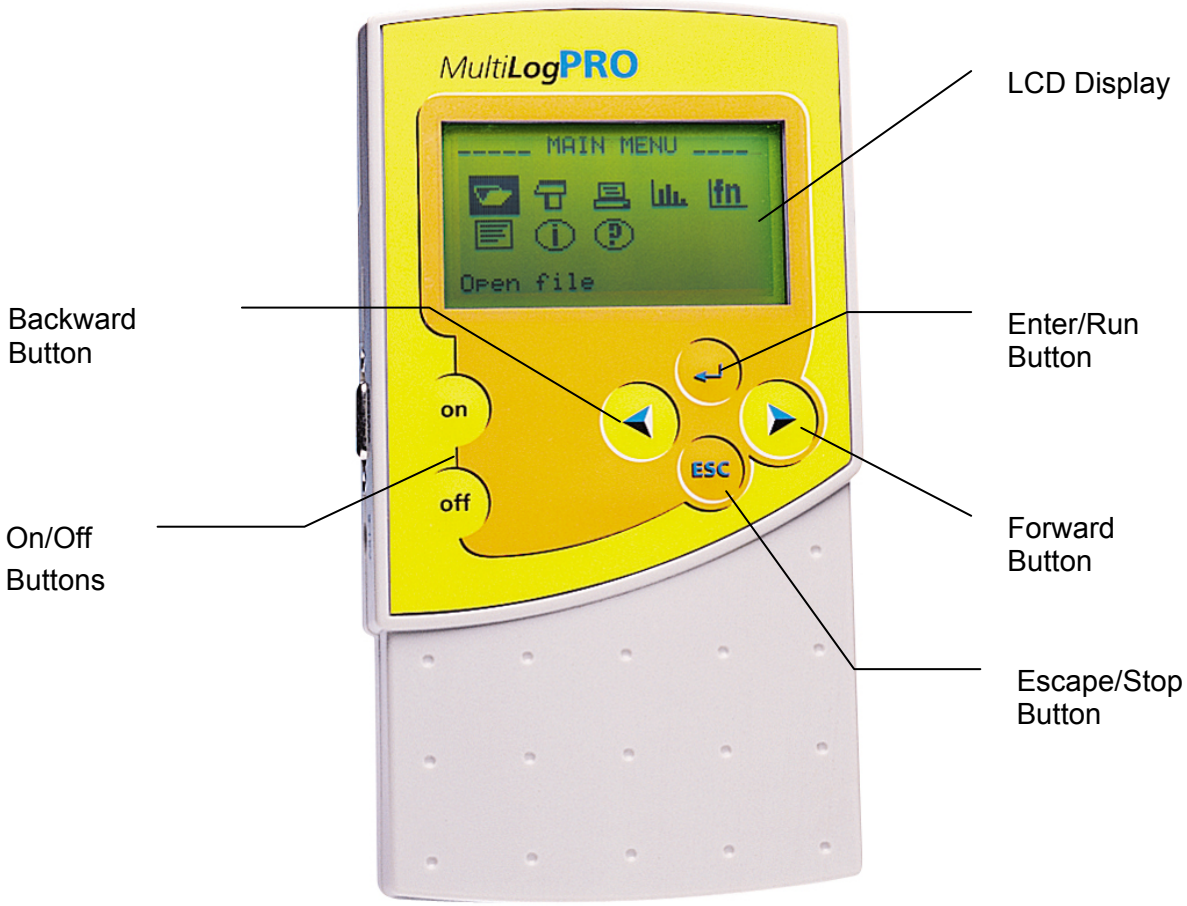


Figure 5: MultiLogPRO front panel

2.2.2. Input Modes

MultiLogPRO has two Input Modes. The default mode is **Auto ID** and the MultiLogPRO is in this mode when turned on for the first time. When using more than 4 sensors, when using third-party sensors, or if you've defined your own sensor, switch to the **8 inputs** mode. Select the **system configuration** menu in the **MAIN MENU** and choose the mode you want (see page 27).

MultiLogPRO saves the current mode selection and will open in that mode the next time you turn it on.

1. **Auto ID**

Automatic sensor identification – just plug in the sensors and the MultiLogPRO prepares itself to collect data from these sensors.

While in this mode you can work with up to 4 sensors simultaneously.

2. **8 Inputs**

This mode enables data logging from up to 8 sensors simultaneously. Connect up to four input splitters (DT011) to multiply the MultiLogPRO's inputs starting with I/O-4 (the splitters **must** be connected in order):

- I/O-4 splits into I/O-4 and I/O-8
- I/O-3 splits into I/O-3 and I/O-7
- I/O-2 splits into I/O-2 and I/O-6
- I/O-1 splits into I/O-1 and I/O-5

In the splitter cable, one of the two wires is marked with arrows - that is the main input (the lower I/O number). The second wire is marked with the letter S (split) - indicating that it is the secondary input (the higher I/O number).

To learn how to switch to 8 inputs mode please refer to section 2.2.9 on page 27.

In this mode there is no automatic sensor identification. Select the sensors manually either from the MultiLogPRO setup menu (see section 2.2.6 on page 22) or using the MultiLab software (see section 3.5.1 on page 64).

Use this mode if you want to work with more than 4 sensors or if you are using third-party sensors.

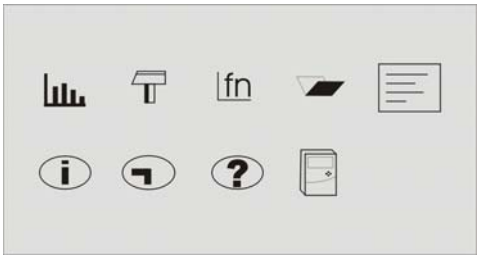
2.2.3. Quick-Start

Before you first use MultiLogPRO, charge the unit for 10 to 12 hours while it is turned off.

1. **Turn on MultiLogPRO**

Press the **on** button

. You will see the initialization screen. MultiLogPRO performs a brief self-check and displays its status including battery level. At this point you can load the last setup you used (see page 27). If you need a new setup wait until you see the Main Menu screen:



2. Plug in the Sensors

Start with the first input on the right. If MultiLogPRO is in Auto ID mode (the default mode) it will display the setup menu and will identify the sensors you've plugged in.

```
      In–1:  Microphone
      In–2:  Light
      In–3:
      In–4:

→     RATE = 10/s
      SAMPLES = 500
      DISPLAY = numeric
```

Note: Sensors must be added successively, starting with input-1. If a single sensor is used it must be connected to I/O-1. If two sensors are used in an experiment, they must be connected to I/O-1 and I/O-2.

The arrow indicates that MultiLogPRO is ready to accept a new sampling rate.

If the MultiLogPRO is in 8 input mode, you have to select the sensors manually (see page 22).

3. Select Rate

Use the **Forward** and **Backward** arrow buttons to select the desired rate, and then press the **Enter** button .

```
      In–1:  Microphone
      In–2:  Light
      In–3:
      In–4:

      RATE      = Every sec
→     SAMPLES   = 500
      DISPLAY   = numeric
```

MultiLogPRO automatically switches to the next step in the setup process and the arrow moves to the *samples* row.

4. Select Total Number of Samples

Use the **Forward** and **Backward** arrow buttons to select the number of samples, and then press the **Enter** button .

```
      In–1:  Microphone
      In–2:  Light
      In–3:
      In–4:

      RATE      = Every sec
      SAMPLES   = 200
→     DISPLAY   = numeric
```

5. Choose Display

Use the **Forward** and **Backward** arrow buttons to select the type of display, and then press the **Enter** button .

```
      In–1:  Microphone
      In–2:  Light
      In–3:
      In–4:

      SAMPLES   = 200
      DISPLAY   = graphic
→     START     = ( > ).
```

6. Start Recording

Press the **Forward** arrow button to start recording.
Or press the **Enter** button if you want to go back to the first item (Rate).

You can stop recording any time by pressing the **Escape** button .

2.2.4. Working with the MultiLogPRO Menus

1. Turning MultiLogPRO On and Off

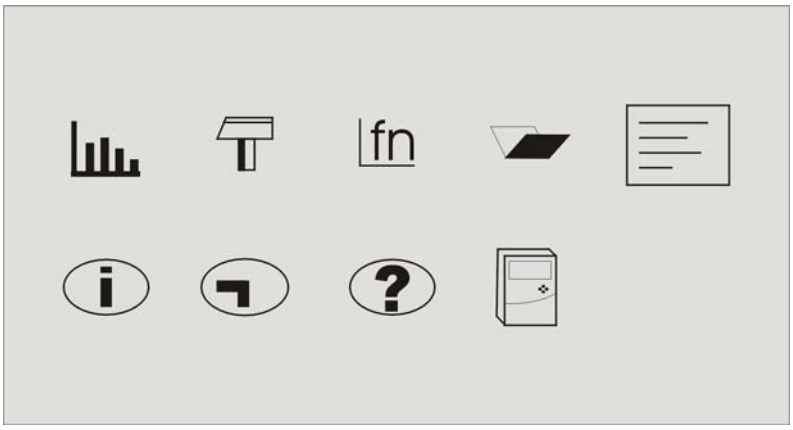
On Turn MultiLogPRO on

Off Turn MultiLogPRO off

Note: Pressing OFF **will not** erase the sample memory. The data stored in the memory will be kept for up to 10 years.

2. Main Menu Display

When turned on, MultiLogPRO opens with a system information window and then displays the main menu:



MultiLogPRO has 9 menus. Use the Forward or Backward **Arrow** buttons to highlight a menu and press the **Enter** button to select it. Then use the **Arrow** buttons to scan the options. Press the **Enter** button to select an option. The MultiLogPRO automatically executes the command.

3. Menu Buttons

Forward Move to the next menu or to the next menu options

Backward Move to the previous menu or menu options

Enter (Start) Enter the selected menu or select the current menu option and move to the next menu command or start recording

Escape (Stop) Return to the main menu or stop recording

4. Menu Icons and Commands

Start Start recording

Press the **Enter** button to start recording

Setup Setup MultiLogPRO in 4 steps:

Rate – Select recording rate

Samples – Select the total number of recording points

Display – Select the way MultiLogPRO will display the data (at a rate of up to 10 samples per second):

- Numeric - Displays the sensor values and the sample number
- Meter - Displays all active sensors in a bar meter display along with their values
- Table - Displays the last 6 values of all the active sensors in a table
- Graphic - Displays a graphic representation of the sampled sensors

At rates higher then 10/s the MultiLogPRO will display the data in a graph at the end of the logging period.

Start – Press the Forward **arrow** to start recording

Function Display statistics of the current data

- Minimum – The minimum graph value
- Maximum – The maximum graph value
- Average – The graph average

Open Open a stored data in graphic display

Use the Forward and Backward **Arrow** buttons to browse the stored files,

press the **Enter** button to open a file

Notes Display experiment notes and instructions

Use the **Arrow** buttons to browse the notes.

You can use the MultiLab software to edit the notes or to write new notes

Info Display system information:

- Number of experiments stored in MultiLogPRO's internal memory
- Memory usage
- MultiLogPRO version
- Battery level (unplug any sensor and external power supply)
- Current date and time

Note: When turning off the MultiLogPRO, the date and time is reset. You restore the current date and time whenever the logger communicates with MultiLab.

Timing Enter to the timing module

You can select between the following timing events:

- Stopwatch
- Time and speed in one photogate
- Time and speed between two photogates
- Time, speed and acceleration between two photogates

Help On-line help and specifications

Configuration Configure the MultiLogPRO:

Input Mode – Select Input Mode: Auto ID or 8 inputs

Clear memory – Delete the stored data files

DO2 – Press the **Forward arrow** button to enter the DO_2 menu

Contrast – Use the **arrow** buttons to tune the screen contrast

Comm. – Press the **Forward arrow** button to connect to a computer or the **Backward arrow** button to connect to TI calculator

2.2.5. Graphic Display

MultiLogPRO will automatically use a graphic display in three cases:

- If the recording rate is 10/s or less and you selected Graphic Display in the setup menu
- Once logging has ended for an experiment with a data recording rate of over 10/s
- When opening a stored recording

The graphic display is available for recordings with up to 4 sensors simultaneously.

1. The Cursor

Use the Cursor in Graphic Display mode to read data values or to zoom in to the area around a selected point. The cursor is displayed automatically after logging has ended, or when opening a stored recording.

1. Use the **Forward** and **Backward** **arrow** buttons to move the cursor.
2. MultiLogPRO displays the point coordinates at the bottom of the graph.
3. If there is more then one sensor, press the **Enter** button to move the cursor to another plot on the graph.

2. Zooming

1. Position the cursor in the area you want to zoom into.
2. Press the two arrow **buttons**, and , simultaneously. You will zoom in around the cursor in a 2:1 ratio.
3. Press the **Escape** button to zoom out.

2.2.6. Measuring Timing Events

MultiLogPRO incorporates an accurate Timer module with resolution of 0.1ms. The timer can measure several types of events triggered by Fourier Systems' photogates:

- Time and speed with one photogate
- Time and speed between two gates
- Time, speed and acceleration between two gates
- Stopwatch

To learn more about the different measurement types see page 46 and page 48.

While in Timer mode MultiLogPRO does not store data. To save timing data in the computer operate the Timer module via MultiLab.

To learn how to use the timer with MultiLab software please see page 45.

To use the photogates together with other sensors operate MultiLogPRO as a data logger and then analyze the photogate data with the aid of MultiLab's Timing Wizard (see page 98).

To perform a timing measurement:

1. Connect one or two photogates to MultiLogPRO

Note: MultiLogPRO must be in PC communication mode (see page 27)

2. Use the **Forward** and **Backward** arrow buttons to navigate to the Timing menu
3. Press **Enter** to display the timing menu:

```
_ _ _ _ _TIMING _ _ _ _ _

→ Mode: Time Speed
  Measure: In1
  Card width: 30mm
  Gates distance: 20cm
  Start  ( > )
```

The arrow indicates that MultiLogPRO is ready to accept the timing mode

4. Use the **arrow** buttons to select the desired timing mode: **Stopwatch**, **Time Speed** or **Time Speed Acc**

1. Stopwatch

```
_ _ _ _ _TIMING _ _ _ _ _

→ Mode: Stopwatch
  Measure:    _ _ _
  Card width: _ _ _
  Gates distance:  _ _ _
  Start  ( > )
```

In this mode MultiLogPRO operates as a standard stopwatch with resolution of 0.01s.

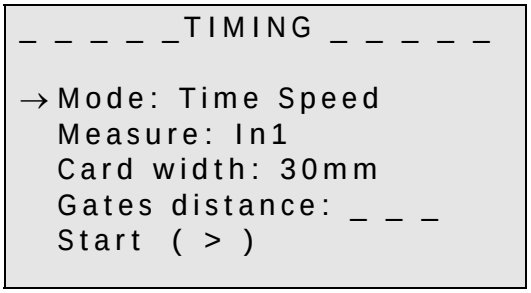
1. Press **Enter** four times, then press the **Forward** arrow to enter the stopwatch mode
2. Press the **Forward** arrow to start measuring time
3. Press the **Forward** arrow a second time to stop the watch
4. Press the **Backward** arrow to reset the watch

5. Press **Escape** to exit the stopwatch mode and return to the timing menu

6. Press **Escape** a second time to return to the main menu

2. Time and Speed

In this mode MultiLogPRO measures time and speed either in one gate or between gates.

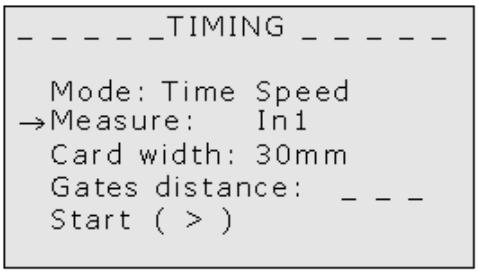


Press **Enter** to select this mode. The arrow moves to the **Measure** row.

Use the **Forward** and **Backward** arrow buttons to select **In1** if you want to measure time and speed in one gate or **In1 → In2** if you want to measure time and speed between two gates.

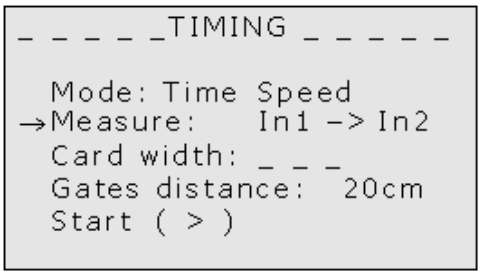
Time and speed at one gate

MultiLogPRO measures the time between blocking and unblocking the photogate at input 1



Time and speed between gates

MultiLogPRO measures the time between blocking the photogate at input 1 and blocking the photogate at input 2



Time and speed at one gate

1. Press **Enter**, then use the arrow buttons to select the card (the body that blocks the gate) width in mm between 0 to 59mm

2. Press **Enter** twice, then use the **Forward** arrow button to enter to a timing standby mode

Time and speed between gates

1. Press **Enter** twice, then use the **Forward** arrow button to select the distance between the photogates in cm between 0 to 99cm

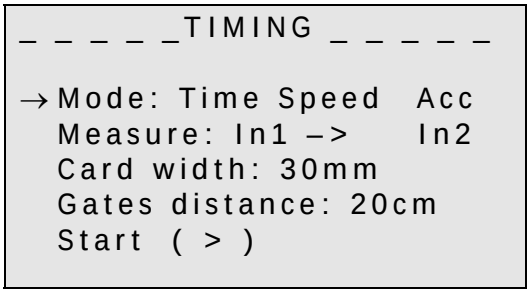
2. Press **Enter**, then use the **Forward** arrow button to enter to a timing standby mode

3. Timing begins each time a body blocks the photogate and ends when unblocking the photogate. MultiLogPRO then displays the elapsed time between entering and leaving the gate and the speed of the body
4. Use the arrow buttons to scroll between the time and speed results
5. Press **Escape** to return to the timing menu
6. Press **Escape** a second time to return to the main menu

3. Timing begins each time a body enters the first photogate (input 1) and ends when leaving the second photogate (input 2). MultiLogPRO then displays the elapsed time between entering the gates and the body's average velocity
4. Use the arrow buttons to scroll between the time and speed results
5. Press **Escape** to return to the timing menu
6. Press **Escape** a second time to return to the main menu

3. Time, Speed and Acceleration

In this mode MultiLogPRO measures the crossing time at the first gate, the time it takes the body to move from one gate to the second gate and the crossing time at the second gate and returns the time between gates, the average speed and the average acceleration.



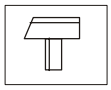
1. Press **Enter** twice, then use the arrow buttons to select the card (the body that blocks the gate) width in mm between 0 to 59mm
2. Press **Enter**, then use the **Forward** arrow button to select the distance between the photogates in cm between 0 to 99cm
3. Press **Enter**, then use the **Forward** arrow button to enter to a timing standby mode

Timing begins each time a body enters the first photogate (input 1) and ends when leaving the second photogate (input 2). MultiLogPRO then displays the elapsed time between entering the gates and the body's average velocity and acceleration

4. Use the arrow buttons to scroll between the time, speed and acceleration results
5. Press **Escape** to return to the timing menu
6. Press **Escape** a second time to return to the main menu

2.2.7. Select Sensors Manually

You must be in 8 input mode to be able to select the sensors manually (see page 16).

1. In the Main Menu screen, use the arrow buttons to select the **setup** menu icon  .
2. Press the **Enter** button to enter the setup menu:

```
→    In–1:  Empty
     In–2:  Empty
     In–3:  Empty
     In–4:  Empty

     RATE = 10/s
     SAMPLES = 500
     DISPLAY = numeric
```

3. Use the **Forward** and **Backward** **arrows** to select the sensor in input 1 and then press the **Enter** button . The arrow indicator will move to the second input.
4. Repeat this procedure with all the sensors you plugged in.
5. After the fourth sensor has been selected, the screen will list the next 4 sensors:

```
→    In–5:  Empty
     In–6:  Empty
     In–7:  Empty
     In–8:  Empty

     RATE = 10/s
     SAMPLES = 500
     DISPLAY = numeric
```

You can press the **Enter** button in the last input if you want to go back to the first input.

6. When you've finished selecting the sensors press the **Escape** button . The arrow indicator will point to the **Rate** command and you must complete the setup, as detailed in section 2.2.3.

Note: When you turn the MultiLogPRO off it will save the setup for the next session.

2.2.8. Load the Last Setup

When you turn MultiLogPRO on, once the self testing has been completed, it will display:

```
___INITIALIZATION___

Init. Display
Init. ADC
Init. RAM
Batt. 99%

ENTER – load setup
```

Press the **Enter** button to load the last setup.

2.2.9. Configure Your MultiLogPRO

Use the **System configuration** menu to select the Input Mode, to clear the MultiLogPRO's memory, to change the screen contrast, or to calibrate the DO_2 sensor.

In the **MAIN MENU** screen, select the **System configuration** icon to display the configuration screen. The default configuration is:

```
→   Input Mode:  Auto ID
    Clear memory ( > )
    DO2 calibration ( > )
    Contrast   ( < )  ( > )
    Comm       ( PC )
```

Use the **Forward** and **Backward** **arrows** to select the mode and then press the **Enter** button to move to the next item. You can press the Escape button to leave the configuration menu at any time, saving the new changes you made. Press **Enter** button in the last item (Contrast) if you want to go back to the first item (Input Mode).

1. Input Mode

Select between **Auto ID** – automatic sensor identification and **8 inputs** – manual sensor selection (See also page 16).

The new configuration will be the default mode until the next time you change it.

2. Clear Memory

Press the **Forward** arrow button if you want to delete all previous data files from the MultiLogPRO.

3. DO_2 Sensor Calibration

If you need to calibrate a DO_2 sensor press the **Forward** arrow button to enter the DO_2 calibration screen:

```
_____ DO2 CAL _____
Use the following
menu to calibrate
the DO2 electrode.

Salinity: 0 ppt
```

Use the **arrow** buttons to select between 0, 5, 10, 15, 20, 25, 30 and 35 ppt and press the **Enter** button to confirm and move to *calibrate altitude*.

Use the arrow buttons to select between 0, 500, 1000, 1500, 2000, 2500, 3000 and 3500 ft and press the **Enter** button to confirm.

MultiLogPRO will display the calculated upper limit of the calibrated range and will exit the DO_2 calibration screen.

The new calibration parameters will be saved until the next time you change them.

4. Screen Contrast

Use the **arrow** buttons to adjust the LCD screen contrast.

Any contrast adjustment will be saved until the next time you change it.

5. Connect to a Computer or to a TI Calculator

Press the **Forward arrow** button to connect to a computer or the **Backward arrow** button to connect to a TI calculator

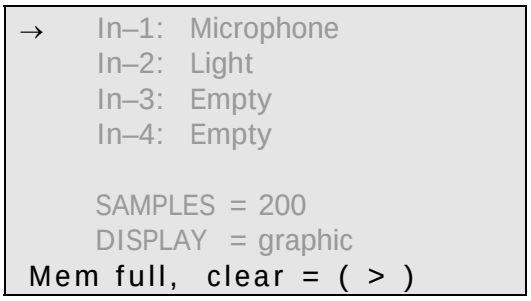
2.2.10. Internal Clock and Calendar

The internal clock is set the first time you use the **Setup** command from the MultiLab software to program the MultiLogPRO. The clock is automatically updated to the PC's time and date whenever you connect your MultiLogPRO to a PC and perform Setup in MultiLab.

When you shut off the MultiLogPRO, the internal clock and calendar is not saved. To restore the clock and calendar, you must reconnect the MultiLogPRO to the PC and Setup the logger again.

2.2.11. Clear the Memory

If you want to start recording and the MultiLogPRO's internal memory is full you will see this message at the bottom of the display:



Press the **Forward** arrow button to clear the memory

In order to clear the MultiLogPRO's memory when it is not full, use the **Memory clear** command from the **Configuration** menu (see page 27), or clear the memory from the **Logger** menu in the **MultiLab software** (see page 70).

2.2.12. Choose the Right Setup

1. **Sampling rate** - The sampling rate should be determined by the frequency of the phenomenon being sampled. If the phenomenon is periodic, sample at a rate of at least twice the expected frequency. For example, sound recordings should be sampled at the highest sampling rate – 20,800/sec, but changes in room temperature can be measured at slower rates such as once per second or even slower, depending on the speed of the expected changes.

   There is no such thing as over-sampling. For extremely smooth graphs, the sampling rate should be about 20 times the expected frequency.

Note: Sampling at a rate slower than the expected rate can cause *frequency aliasing*. In such a case, the graph will show a frequency much lower than expected. In Figure 6 below, the higher frequency sine wave was sampled at 1/3 of its frequency. Connecting the sampled points yielded a graph with a lower, incorrect frequency.

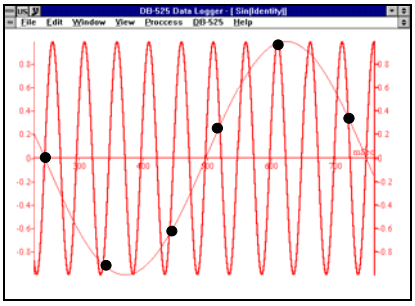


Figure 6: Frequency Aliasing

Manual sampling - use this mode for:

- Recordings or measurements that are not related to time.
- Situations in which you have to stop recording data after each sample obtained, in order to change your location, or any other logging parameter (**Note:** During the experiment *no changes* can be made to the MultiLogPRO's configuration).

To start an experiment using manual data logging, set the **RATE** to *manual* and press the **Enter** button once to start the data recording, then press the **Enter** button each time you want to collect a sample.

You can also perform manual logging via MultiLab (see page 43).

2. **Sampling Points -** After you have chosen the sampling rate, choosing the number of points will determine the logging period: Samples / Rate = Logging time. You can also choose the duration of an experiment first, and then calculate the number of samples: Samples = Logging time × Rate.

Continuous

In the Continuous mode, MultiLogPRO does not save data, and can continue logging indefinitely.

If MultiLogPRO is connected to the PC and the MultiLab software is running, the data is automatically saved to the computer and displayed in a real-time graph.

To operate in Continuous mode select **RATE** equal to or less than 100/s and **SAMPLES = Continuous**.

You can also select Continuous mode directly from the MultiLab software.

Note: MultiLogPRO must be set to a display mode other than graphic in order to enable the Continuous mode.

2.2.13. Programming Rules and Limitations

The following are some rules and limitations you must take into account when programming the MultiLogPRO, as MultiLogPRO integrates all programming limitations automatically. MultiLogPRO will only allow the programming of settings that comply with the rules below.

1. Sampling Points

- Increasing the number of active inputs limits the number of sampling points one can choose. The following condition must be always satisfied: Samples × Active Inputs < Memory. MultiLogPRO's memory is sufficient for 100,000 samples. However, when sampling at rates faster than 100 samples per second the memory can store only two experiments of 32,000 samples each.
- Selection of 100,000 sampling points will create 2 files of 50,000 points each in the data logger's memory

2. Sampling Rate

The number of sensors in use limits the maximum sampling rate:

Number of Sensors	Maximum Sampling Rate
1	20,800 samples per second
2	3,701 samples per second
3	2,631 samples per second
4	2,041 samples per second
5	1,667 samples per second
6	1,409 samples per second
7	1,220 samples per second
8	1,076 samples per second

3. Continuous Sampling

- Continuous sampling is possible up to a maximum sampling rate of 100/s.
- The data must be presented in a display mode other than graphical.

2.3. Sensor Calibration

In this chapter you will learn how to increase the MultiLogPRO system accuracy using calibration. Most of the sensors are linear, i.e. the output level of each sensor changes according to the equation:

$$Y = aX + b$$

Where:

Y - Output of the sensor (voltage level changing from 0 to 5V)

X - Sensor input

a - Sensor gain

b - Sensor offset

The calibration process allows us to control the offset, and in some cases even the gain, of a sensor. The MultiLogPRO system offers four types of calibration:

- Hardware offset calibration
- MultiLogPRO automatic zero calibration
- MultiLab *Sensor calibration*
- Factory calibration (no manual calibration required)

2.3.1. Hardware Offset Calibration

On some of the sensors there is a screw controlling the sensor offset. To calibrate the sensor, rotate this screw until the sensor shows the correct measured value (obtain the actual *correct value* from another source that is known to be accurate).

2.3.2. MultiLogPRO Automatic Zero Calibration

MultiLogPRO is able to automatically calibrate the sensor offset for all analog sensors accurately, quickly, and for every new experiment conducted.

The calibration method is very simple. Whenever you plug in a sensor, the data logger checks to see if the selected sensor measures a value within ±2% of its *zero value*. If so, MultiLogPRO sets that value as zero.

To enable this feature, make sure that the sensors are at their zero values when you plug them in. To ensure the most accurate zero value, follow these instructions for the following sensors:

- Shorten the Voltage sensor plugs
- Leave the Current sensor plugs open
- Cover the Light, Photo Gate, and Microphone sensors
- Insert the pH sensor in a pH 7 solution
- Unload the Force Transducer
- Place the Accelerometer on a stationary surface
- Place the Temperature probes in ice water
- Place the Pressure sensor in a 1 ATM (1013 mb) chamber

2.3.3. pH Temperature Compensation

To compensate a pH sensor for temperature changes, plug the temperature sensor into Input 1, and the pH sensor in Input 2. MultiLogPRO will then display the compensated pH value.

2.3.4. DO_2 Calibration

To calibrate your DO_2 sensor with the right salinity and altitude parameters, use the **DO_2 Calibration** command from the **Configuration** menu (see page 28).

2.3.5. MultiLab Sensor Calibration

The sensors can also be calibrated using the **Calibrate Sensors** option in MultiLab's **Logger** menu. Please refer to section 3.5.7 for more information.

2.3.6. Factory Calibration (No Calibration Required)

All digital sensors that are essentially timers leave the factory fully calibrated, and do not suffer from any accuracy degradation. An example of such a sensor is the Sonic Ranger distance sensor, which measures the time passed from the transmission of a sound pulse to its echo reception.

Chapter 3
MultiLab Software

3.1. Installing the Software

3.1.1. System Requirements

To work with MultiLab, your system should be equipped with the following:

1. Windows

Software

- Windows 98/ME/2000/XP/Vista/7

Note: USBLink data logger is supported by MultiLab running on Windows OS versions: XP, Vista and 7

- Internet Explorer 5.0 or later

Hardware

- Pentium II 600 MHz or higher (Pentium 4, 1.6 GHz or higher is needed for video motion analysis recordings)
- 32 MB RAM (64 MB recommended)
- 10 MB available disk space for the MultiLab application (50 MB to install the supporting applications)
- Free serial or USB port
- To work with the video window your system should be equipped with a video camera, a free USB port and a compatible camera driver
- To be able to record and play voice comments your system should be equipped with a sound card, a microphone and a speaker

2. Mac OS

Software

- Mac OS 9 or Mac OS X
- Web browser

Hardware

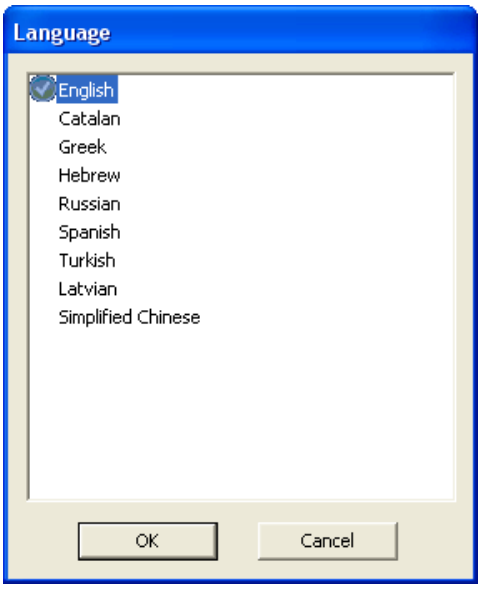
- PowerPC Macintosh G3 300 MHz or higher
- 64 MB RAM
- 15 MB available disk space
- USB port
- Recommended requirements for video recordings:

  PowerPC G4 processor, 500 MHZ or higher, 256 MB RAM, 15 MB free disk space, USB port, camera
- To be able to record and play voice comments your system should be equipped with a microphone

3.1.2. Multiple Language Support

The MultiLab user interface supports several languages, with the default set to English.

1. To change the interface language, go to **Help > Language** in the main menu. The Language dialog will open.



2. Select the language from the list and click **OK**. The MultiLab user interface will automatically switch to the selected language.

For support for other languages not listed, contact your local Fourier distributor.

3.1.3. MultiLab Installation on Windows OS

Note to Windows users: MultiLab needs to modify its folder when running. Ask your system administrator for permission to gain access to all files in the MultiLab folder.

Instructions for installing and uninstalling MultiLab on your PC are provided below. Once the software is installed, you will need to install a USB driver so that your data logger will be detected by the PC. Refer to the relevant section on installing the USB driver.

Installing MultiLab on Windows XP/Vista/7

1. Close all open programs.
2. Insert the CD labeled **MultiLab** into your PC's CD-ROM drive.
3. The Install Wizard will open. Click **Next** to continue the installation.
4. Select the option for agreeing to the terms of the MultiLab license agreement. Click **Next**.
5. Enter user name and company name in the Customer Information window.
6. Select the option regarding for which user the application should be installed. Click **Next**.
7. The default folder where MultiLab will be installed is C:\Program Files\Fourier Systems\MultiLab\. Click **Browse** to change this folder location, or click **Next**.

8. The default folder where the MultiLab data files will be stored is C:\Program Files\Fourier Systems\MultiLab\. Click **Browse** to change this folder location, or click **Next**.
9. MultiLab installation will proceed, followed by installation of associated drivers, Windows Encoders and Quicktime ®.
10. When installation is complete the Install Wizard prompts you to restart the computer. It is recommended to restart the computer now.

3.1.4. MultiLab Installation on Mac OS

1. Insert the CD into your CD drive.
2. Open the CD drive folder and double-click the **MultiLab Installer** icon, then follow the on-screen instructions to complete the installation process.

3.1.5. Installing USB Driver for USBLink

Note: USB driver for USBLink is only supported by Windows XP, Vista and 7.

1. On MultiLab v1.4.22 and higher

Windows XP

1. Launch MultiLab.
2. Connect the mini USB cable to your USBLink and connect the cable to a USB port on your PC. Windows will automatically detect the new device and open the **Found New Hardware Wizard.**
3. Select the option **No, not this time** to prevent Windows from searching for software on the Internet, then click **Next**.
4. Select the option **Install the software automatically (Recommended)** and click **Next**.
5. A window requesting verification of the driver compatibility with Windows XP will pop up. Click **Continue Anyway**.
6. The driver will be installed on the PC.
7. Click **Finish** once the driver has been successfully installed. The USBLink is now ready to use and with the MultiLab software open, the device LED will indicate green, confirming PC detection.

Windows Vista/7

1. Launch MultiLab.
2. Connect the mini USB cable to your USBLink and connect the cable to a USB port on your PC.
3. Windows will automatically detect the new hardware and will automatically install the USB driver for the USBLink.
4. The USBLink is now ready to use and with the MultiLab software open, the device LED will indicate green, confirming PC detection.

2. On MultiLab v1.4.21 and older

Windows XP

1. Connect the mini USB cable to your USBLink and connect the cable to a USB port on your PC. Windows will automatically detect the new device and open the **Found New Hardware Wizard.**
2. Select the option **No, not this time** to prevent Windows from searching for software on the Internet, then click **Next**.

3. Select the option **Install from a list or specific location** and click **Next**.
4. Select the option to search manually for the driver, and select the checkbox **Include this location in the search**. Browse to the location of the USBLink USB driver, either on your MultiLab CD or on your PC hard disk. The name of the driver folder is: **USBLink Driver**, and it resides in the **Drivers** folder in the MultiLab setup directory. The driver file itself will not be displayed, only the folder name.
5. Once you have located the driver folder, click **Next**. The driver will be installed on the PC. You may be asked to verify the author of the driver software. Choose the option to authorize and continue to install the driver.
6. Click **Finish** once the driver has been successfully installed. The USBLink is now ready to use. When the device is detected by the PC the USBLink LED will indicate.

Windows Vista/7

1. Connect the mini USB cable to your USBLink and connect the cable to a USB port on your PC.
2. Windows will not automatically detect the new hardware. From the **Start** menu, select **Computer**, and then click **System Properties** in the upper menu bar. In the **System** window, select **Device Manager** from the **Task** list on the left of the window.
3. In the Device Manager, locate the **Other devices** tree and right click on the **USBLink** item. Select the **Update Driver Software** menu item.
4. Select the **Browse my computer for driver software**, and click **Next**.
5. Browse to the location of the USBLink USB driver, either on your MultiLab CD or on your PC hard disk. The name of the driver folder is: **USBLink Driver**, and it resides in the **Drivers** folder in the MultiLab setup directory. The driver file itself will not be displayed, only the folder name.
6. Once you have located the driver folder, click **Next**. The driver will be installed on the PC. You may be asked to verify the author of the driver software. Choose the option to authorize and install the driver.
7. Click **Close** once the driver has been successfully installed. The USBLink is now ready to use. When the device is detected by the PC the USBLink LED will indicate.

3.1.6. Installing USB Driver for MultiLogPRO

1. On MultiLab v1.4.22 and higher

Windows 2000 and higher

With the release of MultiLab v1.4.22 installation of the USB driver for the MultiLogPRO is performed automatically as part of the main MultiLab software installation. When connecting the MultiLogPRO to the PC for the first time, it will be automatically recognized by MultiLab.

2. On MultiLab v1.4.21 and older

Pre-Windows XP systems

1. Insert the MultiLab installation CD into your CD drive.
2. Connect your data logger to a USB port on your PC and turn the data logger on. Windows will automatically detect the new device and open the **Found New Hardware Wizard**.

3. Select **Specify the location of the driver**, and then click **Next**.
4. Select **Search for the best driver for your device**, then check the **Removable Media** checkbox, and then click **Next**. Windows will automatically detect and copy the necessary files to your system.
5. Click **Finish**. Windows will open the **Found New Hardware Wizard** for the second time.
6. Click **Next** to complete the installation. Windows will automatically install the necessary components on your system.
7. Click **Finish.**

Windows XP

1. Connect your data logger to a USB port on your PC and turn the data logger on. Windows will automatically detect the new device and open the **Found New Hardware Wizard.**
2. Select the **No, not this time** to prevent Windows from searching for software on the Internet, then click **Next**.
3. Select the option **Install from a list or specific location** and click **Next**.
4. Select the option to search manually for the driver, and select the checkbox **Include this location in the search**. Browse to the location of the USB driver, either on your MultiLab CD or on your PC hard disk. The name of the driver folder is: **Logger USB Driver**, and it resides in the **Drivers** folder in the MultiLab setup directory.
5. Once you have located the driver folder, click **Next**. The driver will be installed on the PC.
6. Click **Finish.** Windows will open the **Found New Hardware Wizard** for the second time.
7. Click **Next** to complete the installation. Windows will automatically install the necessary components on your system.
8. Click **Finish**. The logger is ready to use and will now be detected by the PC.

Windows Vista/7

1. Connect your data logger to a USB port on your PC and turn the data logger on.
2. Windows will not automatically detect the new hardware. From the **Start** menu, select **Computer**, and then click **System Properties** in the upper menu bar. In the **System** window, select **Device Manager** from the **Task** list on the left of the window.
3. In the Device Manager, locate the **Other devices** tree and right click on the **USB Serial Port** item. Select the **Update Driver Software** menu item.
4. Select the **Browse my computer for driver software**, and click **Next**.
5. Browse to the location of the USB driver, either on your MultiLab CD or on your PC hard disk. The name of the driver folder is: **Logger USB Driver**, and it resides in the **Drivers** folder in the MultiLab setup directory.
6. Once you have located the driver folder, click **Next**. The driver will be installed on the PC.
7. Click **Close** once the driver has been successfully installed. The logger is ready to use and will now be detected by the PC.

3.1.7. Uninstalling MultiLab

Note: Uninstalling MultiLab removes program files only. Project files and worksheets you created or modified in MultiLab will remain on your system and there is no need to create backups.

To uninstall the software on Windows XP:

1. From the **Start** menu select **Settings** then click **Control Panel**.
2. Double click **Add or Remove Programs**.
3. Select **MultiLab** from the list of programs.
4. Click **Remove**.
5. In the following dialog box, click **Yes** to confirm that you want to remove MultiLab.
6. When uninstall is complete you will be prompted to restart the computer. Select **Yes**.

To uninstall the software on Windows Vista/7:

1. From the **Start** menu select **Control Panel**.
2. Select **Programs > Uninstall a program**.
3. Select **MultiLab** from the list of programs and click **Uninstall** from the top of the window.
4. In the following dialog box, click **Yes** to confirm that you want to remove MultiLab.

3.2. Overview

3.2.1. MultiLab On-screen Layout

MultiLab is a comprehensive program that provides you with everything you need in order to collect data from Fourier data loggers such as the USBLink and MultiLogPRO. You may display the data in graphs, meters and tables, analyze it with sophisticated analysis tools and view online or recorded video movies of the actual experiment.

The Video Motion Analyzer module enables you to capture position and time from video movies and analyze the data with MultiLab's analysis tools

The program includes four windows: A graph window, table window, video window and a navigation window called the Data Map. You can display all four windows simultaneously or any combination of the four.

The most commonly used tools and commands are displayed on three toolbars. Tools that relate to all aspects of the program and tools that control the data logger are located in the main (upper) toolbar. Tools specific to the graphs are located on the graph toolbar and tools specific to the tables are located on the table toolbar.

Another useful feature is the Workbook. A workbook is a lab activity that gives the student a step-by-step preview of the activity and then automatically configures the MultiLab program and the sets up the data logger so that the student can begin collecting the data. You can open an existing workbook or create a new one from the Workbook menu.

3.2.2. MultiLab Window Layout

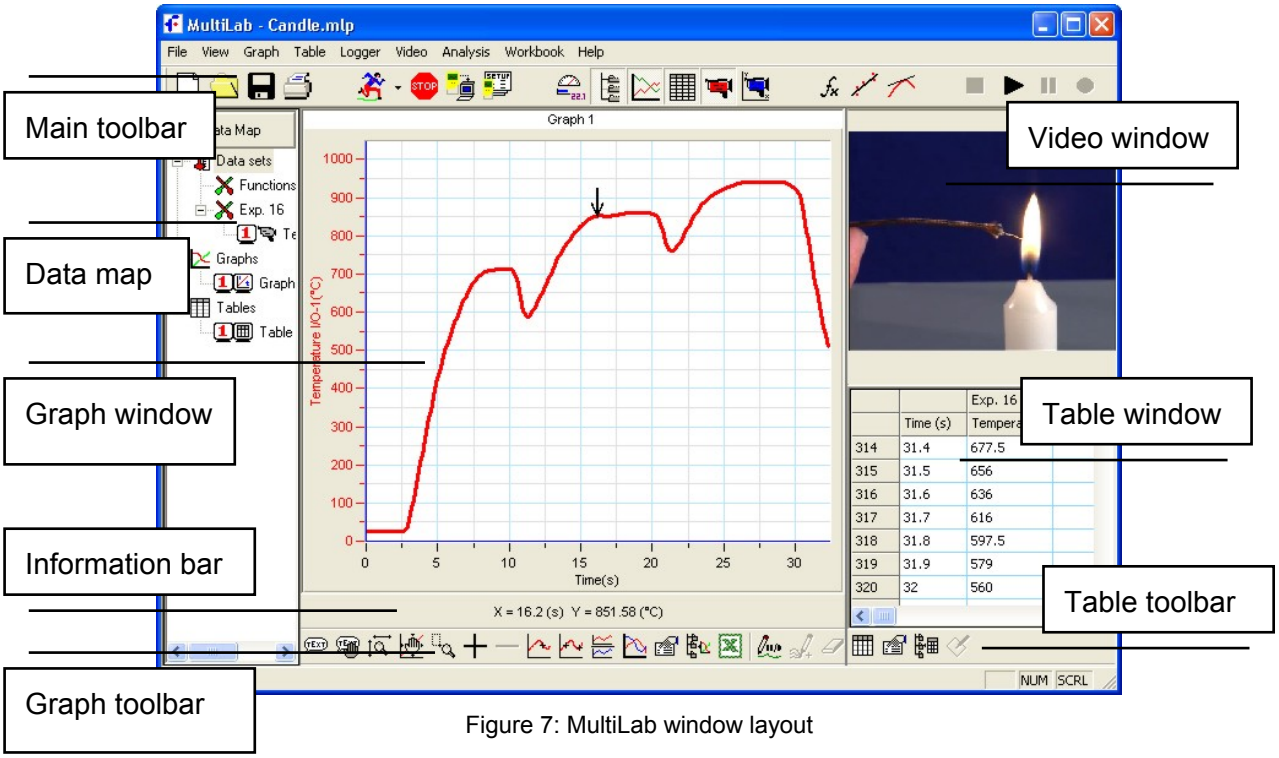


Figure 7: MultiLab window layout

3.2.3. Working with Projects

Every time you start a new experiment, MultiLab automatically creates a new project file. All the information you collect and process for a given experiment is stored in a single project file. Each of these files contain all the data sets you collect with the data logger, the analysis functions you've processed, the video files you've recorded, specific graphs and tables you've created, and the MultiLab settings for the experiment.

Note: All data sets in a single project must be with the same sampling rate.

3.3. Getting Started

This section outlines getting started with using the USBLink and MultiLogPRO data loggers.

3.3.1. Set up a Recording Session

1. Prepare the USBLink

1. Connect USBLink to the PC (see page 4).
2. Plug in any external sensors.
3. Launch the MultiLab software.

2. Prepare the MultiLogPRO

1. Connect MultiLogPRO to the PC (see page 13).
2. Turn on MultiLogPRO.

Note: MultiLogPRO must be in PC communication mode (see page 27).

3. Plug in any external sensors.
4. Launch the MultiLab software.

3. Enable Video Recording

Note: *Do not* plug in the PC camera before you have installed the camera driver.

To display the video window and enable online video and video recording:

1. Connect the camera to the PC
2. Click **Video** on the menu bar, then click **Enable video**

MultiLab will remember the video settings until the next time you change them.

Note: if more than one video source is connected to your computer MultiLab will use the default source. To select another source click **Video** on the menu bar and click **Select video device**, then select the desired source from the drop list that opens and click **OK.**

3. Click **Video** on the main toolbar to display the video window.
4. Point the camera to the experiment setup.

4. Setup the USBLink/MultiLogPRO

1. Click the **Setup Wizard** button on the main toolbar. For USBLink, and for MultiLogPRO, .
2. Follow the instructions in the **Setup Wizard** (see page 64).

5. Start Recording

Click **Run** on the toolbar to start recording.

- For the USBLink, the data is continuously streamed online into the MultiLab software, whatever the sampling rate. Therefore it is always visible to the viewer during the actual measurement.
- For the MultiLogPRO, if the recording rate is 100 measurements per second or less, MultiLab automatically opens a graph window displaying the data in real-time, plotting it on the graph as it is being recorded. If the recording rate is higher than 100/s, the data will be downloaded and displayed automatically once the data recording is finished.

You can stop recording anytime by clicking **Stop** on the toolbar.

3.3.2. Data Recording Options

To set the behavior of the data display when you start a new recording session, click on the **down arrow** next to the **Run** button , and select one of the following:

1. Single Measurement

MultiLab will open a new project file every time you start a new recording session.

2. Replace

MultiLab will display the new data set in place of the old one. The project's old data sets will still be available in the same project file. They will be listed in the Data Map and you can add them to the display at any time.

3. Add

MultiLab will add the new data set to the graph in addition to the old ones.

Note: A maximum of eight data sets can be displayed on the graph at the same time.

3.3.3. *Manual Sampling*

Use this mode for:

- Recordings or measurements that are not related to time.
- Situations in which you have to stop recording data after each sample obtained, in order to change your location, or any other logging parameter (**Note:** During the experiment *no changes* can be made to the MultiLogPRO's configuration).

To start an experiment using manual data logging, set the rate to manual and click **Run** once to start the data recording, and then press the **Enter** button each time you want to collect a sample.

You can also perform manual logging via MultiLogPRO (see page 29).

3.3.4. *Online Video*

MultiLab enables you to view online video of your experiment along with the data display, as well as to record video movies of the experiment and to replay them simultaneously with the data graph. You can also add voice comments to the video recordings.

To work with the video window your system should be equipped with a video camera.

To be able to record and play voice comments your system should be equipped with a sound card, a microphone and a speaker.

1. Online Video

The online video will start playing when you open the Video window. Click **Video** on the main toolbar to display the video window and enable video (see page 41).

2. Recording

1. From the **Video** menu select **Enable video**.
2. Click **Record** on the right-hand side of the toolbar to start video recording.
3. Click **Run** to start data recording.
4. Once the data logging has finished, click **Stop Video Recording** .
5. Click **Replay** to replay both the data graphing process the video recording simultaneously.

Note: Saving the file will automatically save the video as well.

3. Replaying an Experiment

To simultaneously replay the video and the data graphing process of a saved file:

1. Open the file (see page 50).
2. Display the data on the graph (see page 61).
3. Click **Replay** .

4. Video and Audio Properties

To set the video properties click **Video** on the menu bar, then click **Video properties** to open the video properties dialog box:

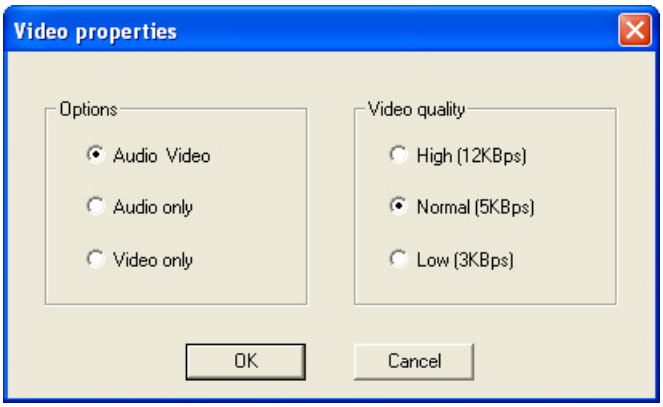


Figure 8: Video properties dialog box

Changing Video Quality

The video default quality is **Normal**; click another option to select either higher quality (12 KBps) or lower quality (3 KBps). Changing the video quality not only affects the image quality, but the recorded file space and the computer's performance as well. A higher video quality means more disk space is used, which can slow down the computer's performance.

Audio Visual Options

The default option is **Audio_video**. That means that both video and audio are enabled and you can record voice comments along with the video. If you plan to record video only, select the **Video only** option. If you plan to record voice comments only select the **Audio only** option.

3.3.5. Download Data from the USBLink

There is no download function for the USBLink as it doesn't have onboard memory. All data is recorded directly into the MultiLab software.

3.3.6. Download Data from the MultiLogPRO

Whenever data is received from the MultiLogPRO, it is accumulated and displayed automatically by MultiLab. There are two modes of communication: Online and Post-Experiment.

Online communication

When MultiLogPRO is connected to the PC and is programmed to run at sampling rates of up to 100/s, MultiLogPRO transmits each data sample immediately, as it is recorded, to the PC. The software thus displays the data in real-time in both the graph window and the table window.

When MultiLogPRO is connected to the PC and programmed to run at a sampling rate faster than 100/s, data is accumulated in MultiLogPRO‘s internal memory but is not transmitted directly to the PC until the recording period has ended. Once the recording has ended, the data is automatically downloaded to the PC and displayed.

Off-line data logging

To download data that was recorded offline, or while MultiLogPRO was not connected to a PC, connect MultiLogPRO to the computer, run the MultiLab program and click **Download** on the toolbar. This will initiate the Post-Experiment Data Transfer communication mode. Once the transfer is complete, the data will be displayed automatically in the graph window and in the table window. If there are several experiments stored in the MultiLogPRO, the first download will bring up the most recent experiment; the second download will bring up the earliest file, the third download will bring up the second earliest file, and so on.

To download a particular experiment, choose **Selective Download** from the **Logger** menu, then select the experiment’s number in the Download dialog box.

Click **Cancel** in the Download progress window at any time to stop downloading the data.

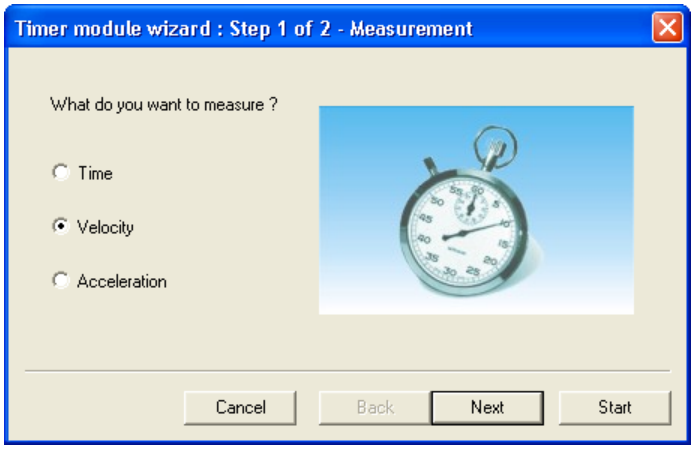
3.3.7. The Timer Module

MultiLab enables you to measure timing events with the data logger’s Timer module (see page 22).

To use the photogates together with other sensors operate the data logger and then analyze the photogates data with the aid of MultiLab's Timing Wizard (see page 98).

1. Working with the Timer Module Wizard

1. Connect the data logger to the computer
2. Connect one photogate to input 1 of the data logger or two photogates to inputs 1 and 2 (according to the event method)
3. Click **Logger** on the menu bar, and then click **Timer Module Wizard** to open the Timer module wizard:



4. Click an option to select measurement: **Time**, **Velocity** or **Acceleration**

5. Click **Next** to move to step 2 of the wizard:

6. Click an option to select the measuring method

7. If required enter the body's width in mm (an integer between 0 to 59), or the distance between the gates in cm (an integer between 0 to 99) in the appropriate edit box (in velocity and acceleration measurements only)

8. Click **Start** to enter to a timing standby mode

Timing begins each time a body blocks the photogate in input 1 and ends when unblocking the photogate in input 1 or input 2 (according to the event method). MultiLab displays the results in a bar graph and in the table.

You can repeat as many measurements as you want. After each event MultiLab adds the results as a new bar in the graph and as a new raw in the table.

To exit the timing mode click Stop

on the main toolbar.

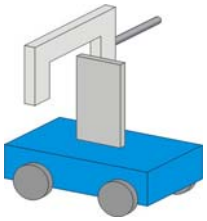
2. Measuring Methods

The Timing Wizard offers you various methods of analyzing the different measurements. In some measurements you will be asked to enter the dimension of the moving body, or the distance between the two photogates to allow for the calculation of velocity and acceleration.

The methods depend on the selected measurement:

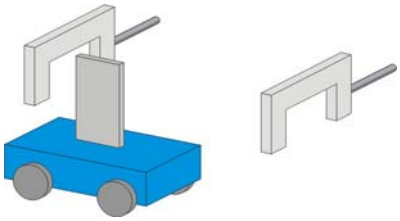
Time

- At one gate



Measures the time it takes the body to cross the photogate (between blocking and unblocking the infrared beam)

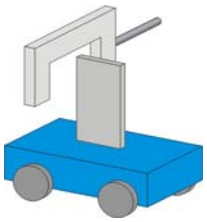
- Between gates



Measures the time it takes the body to move from one photogate to the second photogate (between blocking the first and blocking the second infrared beams)

Velocity

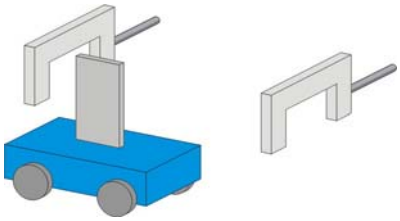
- At one gate



Measures the time it takes the body to cross the photogate (between blocking and unblocking the infrared beam) and returns the velocity.

You should enter the body's width in mm

- Between gates

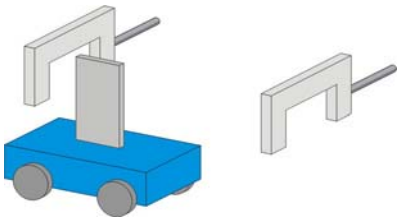


Measures the time it takes the body to move from one photogate to the second photogate (between blocking the first and blocking the second infrared beams) and returns the average velocity.

You should enter the distance between gates in cm.

Acceleration

- Between gates



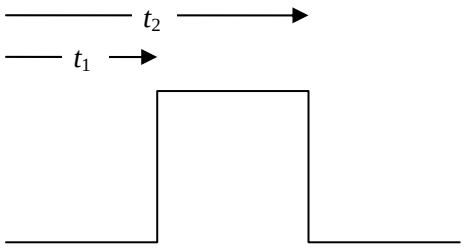
Measures the crossing time at the first gate, the time it takes the body to move from one gate to the second gate and the crossing time at the second gate and returns the average acceleration.

You should enter the body's width in mm.

3. Time Schemes and Calculations

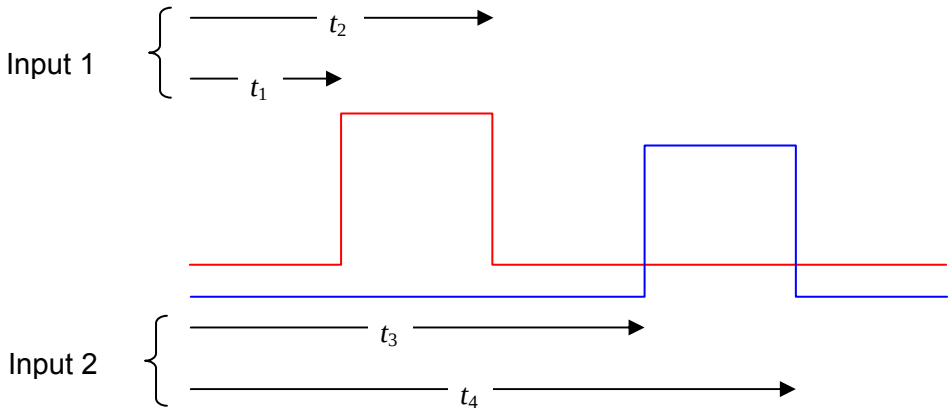
TIME MEASUREMENTS

At one gate



Result: $\Delta t = t_2 - t_1$

Between gates

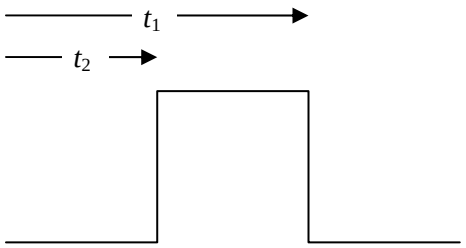


Result: $\Delta t = t_3 - t_1$

VELOCITY

At one gate

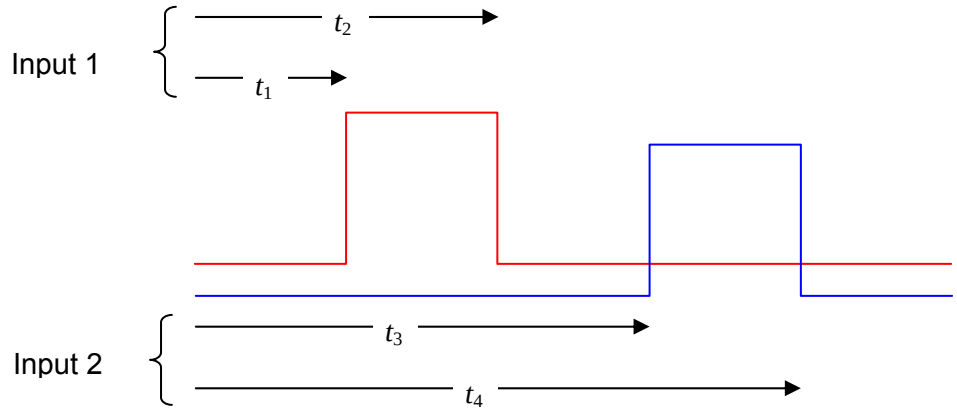
Required parameters: w – The body's width



Result: $v = \frac{w}{\Delta t}; \quad \Delta t = t_2 - t_1$

Between gates

Required parameters: L – The distance between gates

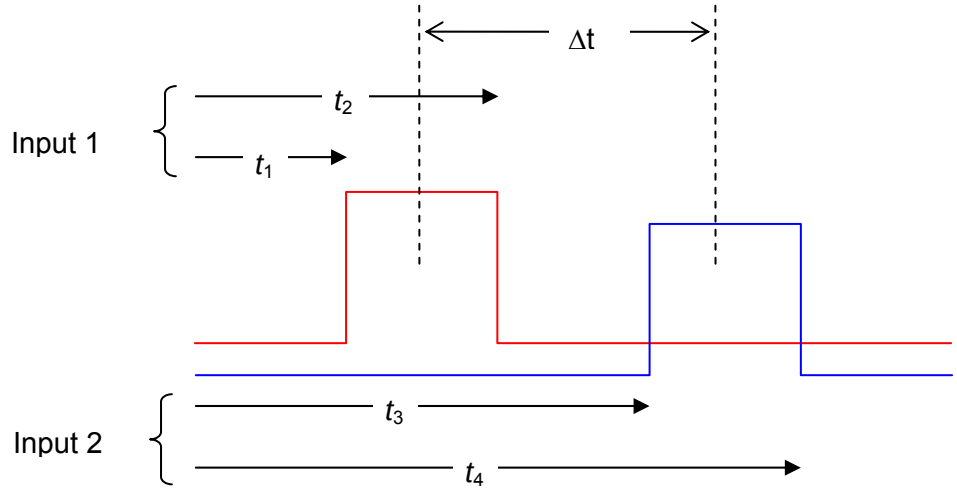


Result: $v = \frac{L}{\Delta t}; \quad \Delta t = t_3 - t_1$

ACCELERATION

Between gates

Required parameters: w – The body's width



$$v_1 = \frac{w}{t_2 - t_1}; \quad v_2 = \frac{w}{t_4 - t_3}$$

Result:

$$\Delta t = \frac{t_4 + t_3 - t_2 - t_1}{2}$$

$$a = \frac{v_2 - v_1}{\Delta t}$$

3.3.8. Save Data

Click **Save** on the main toolbar to save your project. This will save all the data sets, graphs, tables and video movies under one project file.

Saving the project will also save any special formatting and scaling you did.

If you made any changes to a previously saved project, click **Save** to update the saved file or select **Save as…** from the file menu to save it under another name.

Note: To delete a specific data set, graph or table from the project, use the Data Map (see page 61).

To remove unwanted data from a specific data set, apply the crop tool (see page 98).

3.3.9. Open a File

1. Click **Open** on the main toolbar.
2. Navigate to the folder in which the project is stored.
3. Double click the file name to open the project.

MultiLab opens the project and displays the first graph on the graph list. If the project does not include saved graphs, the file opens with an empty graph window. Use the Data Map (see page 61) to display the desired data set.

3.3.10. Create a New Project

There are three ways to create a new project:

1. Open the MultiLab program, which will open a new file each time.
2. When working in Single Measurement mode, a new project is opened every time you click on the **Run** button to start a new recording
3. Any time you click **New** button on the toolbar.

3.3.11. Import Data

Any file that is in comma separated values text format (CSV) can be imported into MultiLab.

To import a CSV file:

1. Click **File** on the menu bar, then click **Import CSV file**.

2. In the dialog that opens, next to **Look in**, navigate to the drive and folder that contains the CSV file.

3. Select the file.

4. Click **Open**.

Tips:

To create a text file in a spreadsheet:

1. Open a new spreadsheet.

2. Enter your data according to the following rules:

   a) The first row should contain headers. Each header includes the name of the data set and units in brackets, e.g. Distance (m).

   b) The first column should be the time. The time interval between successive rows must match the time intervals accepted by MultiLab. You can export MultiLab files to Excel to learn about these time formats.

   See for example the table below:

	A	B	C
1	t(s)	x(m)	y(m)
2	0	0	5
3	0.1	0.95	4.05
4	0.2	1.8	3.2
5	0.3	2.55	2.45
6	0.4	3.2	1.8
7	0.5	3.75	1.25
8	0.6	4.2	0.8

3. On the **File** menu, click **Save As**.

4. In the **File name** box, type a name for the workbook.

5. In the **Save as type** list, click the **CSV** format.

6. Click **Save**.

To import files that were previously exported from MultiLab open MultiLab and import the file as described above as they are already in CSV format.

3.3.12. Print

1. Print a Graph

1. Click **Print** on the main toolbar.

2. Select the **Graph 1** option (when in split graph mode you can choose between Graph 1 and Graph 2).

3. Click **Print** to open the print dialog box.

4. Click **OK**.

MultiLab will print exactly what you see in the graph display.

2. Print a Table

1. Click **Print** on the main toolbar.
2. Select the **Table** option.
3. If you want to print only a specific range, uncheck the **Print all data** check box and type the desired row numbers into the **To** and **From** edit boxes
4. Click **Print** to open the print dialog box.
5. Click **OK**.

3.4. Viewing the Data

3.4.1. Display Options

The MultiLab program screen consists of four parts: Graph window, table window, video window and Data Map window. You can display all four parts simultaneously (the default view) or any combination of the four.

The graph window is the main window by default and is and displayed in the center of the application window. To specify other window as the main window:

1. Click **View** on the menu bar, and then click **View selection** to open the View selection dialog box:

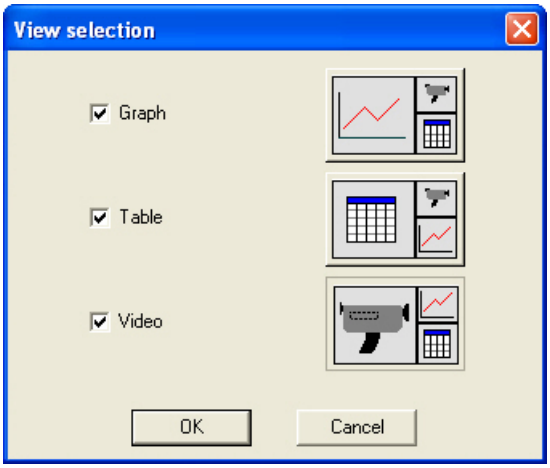


Figure 9: View selection dialog box

2. Check the checkbox next to any window you'd like to include in the view.
3. Click the window display type you want.
4. Click **OK**.

In addition to these sections, you have the option to display an on-screen meter for each of the sensors (see page 61).

3.4.2. Graph Display

Click **Graph** to display or hide the graph. The default graph display is the data set or sets plotted vs. time, but you can change the X-axis to represent any of the individual data sets (see page 56).

The graph usually displays all the data sets of a given recording, but you can use the Data Map to remove one or more of the sets from the graph (see page 61).

In order to keep the graph clear and simple, only two Y-axes are shown on the graph at once. If there are three curves in the graph, one of the Y-axes is hidden. To make this axis visible, select the corresponding plot with the cursor (see section 2 below).

You can identify the Y-axis by its color, which matches the plot color.

1. Split Graph View

MultiLab enables you to display your data in two separate graphs within the graph window.

1. Click **Split graph** on the graph toolbar to split the graph window into two separate graphs.

2. Click **Edit graph** on the graph toolbar to open the Edit graph dialog box.

3. Choose which data sets to display on each of the graphs (or use the Data Map to do so – see page 61).

4. To return to the single graph display, click **Split graph** a second time.

2. The Cursor

You can display up to two cursors on the graph simultaneously.

Use the first cursor to display individual data recording values, to select a curve or to reveal the hidden Y-axis.

Use two cursors to display the difference between two coordinate values or to select a range of data points.

To display the first cursor:

Double click on an individual data point or click **1st Cursor** on the graph toolbar. You can drag the cursor with the mouse onto any other point on the plot, or onto a different plot. For finer cursor movements use the forward and backward keys on the keyboard.

The coordinate values of the selected point will appear in the information bar at the bottom of the graph window.

To display the second cursor:

Double click again anywhere on the graph area or click **2nd Cursor** on the graph toolbar.

The information bar will now display the difference between the two coordinate values. If the x-axis is time 1/dt will also be displayed.

To remove the cursors:

Double click anywhere on the graph area, or click **1st Cursor** a second time.

To remove the 2nd cursor:

Click **2nd Cursor** a second time.

To display the cursors in split graph mode:

To display the cursors on the upper graph, use the same method as for single graph mode.

To display the cursors on the lower graph, you must first remove them from the upper graph and then double click anywhere on the lower graph to display the first cursor. Double click a second time to display the second cursor, and double click a third time to remove the cursors.

3. Zooming

To zoom in to a specific data point

1. Select the point with the cursor (see above).
2. Go to **Graph > Zoom in** on the main menu.
3. To reverse the operation, go to **Graph > Zoom out** on the main menu or click **Autoscale** on the graph toolbar.

To zoom in to a range

1. Select the range with both cursors.
2. Go to **Graph > Zoom in** on the main menu.
3. To reverse the operation, go to **Graph > Zoom out** on the main menu or click **Autoscale** on the graph toolbar.

To zoom in to a specific area

Click **Zoom to selection** on the graph toolbar and drag the cursor diagonally to select the area you want to magnify. Release the mouse button to zoom in to the selected area.

Click **Zoom to selection** a second time to disable the zoom tool.

Autoscale

Click **Autoscale** on the graph toolbar to view the full data display, or double click on an axis to auto scale that axis alone.

4. Manual scaling

1. Click **Graph properties** on the graph toolbar to open the Graph properties dialog box.
2. Select the **Scale** tab, and choose the axis you want to scale in the **Select axis** drop down menu.
3. Uncheck the **Autoscale** check box and enter the new values in the edit box.
4. Click **OK**.

To manually scale a specific axis, right click on the axis to open its Properties dialog box.

To restore auto scaling click **Autoscale** .

5. The Stretch/Compress Axis tool

Move the cursor onto one of the graph axes. The cursor icon changes to the double arrow symbol (↔), indicating that you can stretch or compress the axis scale. Drag the cursor to the desired location. Repeat the procedure for the other axis if necessary.

Double click on the axis to restore auto scaling.

6. Panning

Use the pan tool after zooming in to see any part of the graph that is outside the zoomed area.

To do this, click **Pan** on the graph toolbar, then click anywhere on the graph and drag the mouse to view another area.

Click **Pan** a second time to disable the Pan tool.

7. Edit the Graph

Use the Edit graph dialog box to select which data sets to display on the graph's Y-axis and to change the X-axis from time, to one of the data sets.

1. Click **Edit graph** on the graph toolbar to open the Edit graph dialog box:

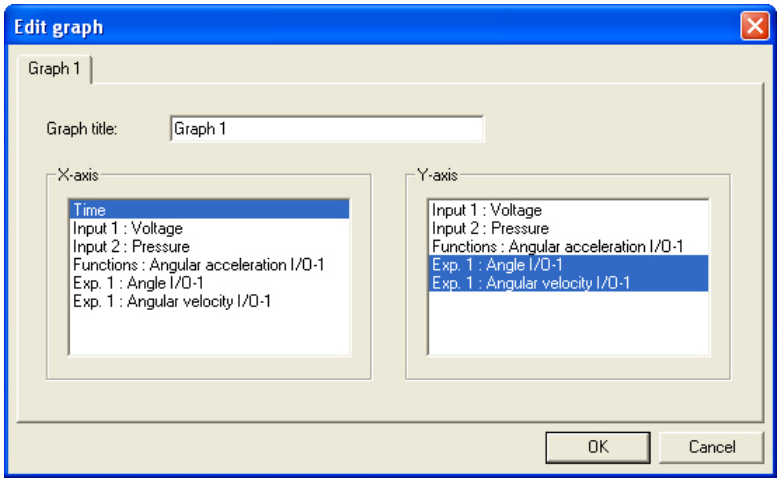


Figure 10: Edit graph dialog box

2. To select a data set to display on the Y-axis, click on the data set's name in the **Y-axis** list. To display more than one curve, click on the data sets you want.

3. A list entry that begins with an Experiment (Exp.) number denotes a recorded data set. A list entry that begins with an input number denotes the next recording and will be displayed on the graph the next time you start a recording.

4. To deselect a data set click on the set a second time.

5. To select a data set for display on the X-axis, click on the data set's name in the **X-axis** list. You can only select one data set at a time for the X-axis.

6. Type the title of the graph in the **Graph title** edit box (optional).

7. Click **OK.**

8. Format the Graph

You can change the data line's color, style and width. You can also add markers that represent the data points on the graph and format their style and color.

The color of the Y-axis matches the corresponding plot's color and will automatically change with any change made to the color of the corresponding plot.

1. Click **Graph properties** on the graph toolbar to open the **Graph properties** dialog box.

2. Select the **Lines** tab, and then select the plot or axis you want to format in the **Select plot** drop list.

3. From here you can format the line's color, style and width, as well as the markers' color and style. To remove the line or the marker, uncheck the corresponding **Visible** check box.

4. Click **OK**.

5. To restore the default formatting, click **Restore default**.

9. Change the Graph's Units and its Number Format

1. Click **Graph properties** on the graph toolbar to open the graph properties dialog box

2. Select the **Units** tab, and then select the plot or axis you want to format in the **select plot** drop list.

3. Choose the prefix option you want.

4. Select the desired number of decimal places.

5. To display numbers in scientific format, check the **Scientific** check box.

6. Click **OK**.

10. Add Annotations to the Graph

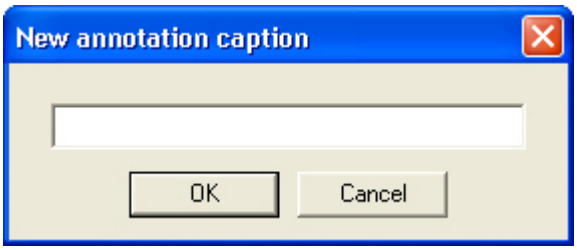
You can add annotations to the graph. An annotation is always connected to a certain data point.

To view annotations:

Click **Graph** on the menu bar and then select **Show annotation** (this option is usually selected by default).

To add an annotation:

1. Place a cursor on the desired point.
2. Click **Add new annotation** on the graph toolbar to display the new annotation caption edit box.



3. Type in the text, and then click **OK**.

To move an annotation:

1. Click **Move annotation** on the graph toolbar.
2. Click on the annotation you want to move, then drag if to the new position.
3. Click **Move annotation** a second time to exit the move annotation mode.

To edit an annotation:

1. Place a cursor on the point to which the annotation is connected.
2. Click **Graph** on the menu bar, and then click **Edit annotation**.
3. Edit your annotation, and then click **OK**.

To delete an annotation:

1. Place a cursor on the point to which the annotation is connected.
2. Click **Graph** on the menu bar, then click **Delete annotation**.

To hide all annotations:

Click **Graph** on the menu bar and then click **Show annotation** to uncheck it.

11. Add a Graph to the Project

MultiLab displays new data in the graph window every time you start a new recording. You can always display previous data using the **Edit graph** dialog box or by double-clicking on the data's icon in the **Data Map.** If you want to save a graph that you created to your project, or to update a saved graph with changes you made, use the **Add to project** tool:

Click **Add to project** on the graph toolbar.

3.4.3. The Table Display

Click **Table** to display or to remove the table window.

When you start a new recording, MultiLab displays the new data on the table.

To add or remove columns from the table, use the **Edit table** tool (see below).

1. Editing Data Values

You can change the value of any data point. When any value is changed, MultiLab automatically creates a copy of the data set and leaves the original data unchanged. To do this:

1. Select a data cell by clicking on it.
2. Type in the new value.
3. Press **Enter** on the keyboard to accept (you can also press Tab or the arrow keys to accept and move to the next cell).

2. Editing the Table

To add or remove data sets from the table:

Click **Edit table** on the table toolbar to open the Edit table dialog box:

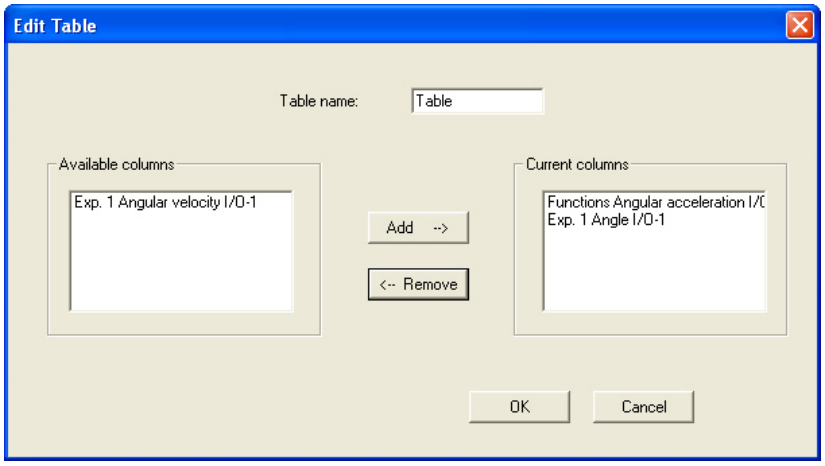


Figure 11: Edit table dialog box

To add columns to the table:

1. Select one or more of the data sets from the **Available Columns** list.
2. Click **Add**.

To remove columns from the table:

1. Select one or more of the data sets from the **Current Columns** list.
2. Click **Remove**.
3. Click **OK**.

3. Formatting the Table

Changing column width

Drag the boundary on the right side of the column heading until the column is the desired width.

Changing row height

Drag the boundary below the row heading until the row is the desired height.

Formatting the fonts

1. Click **Table properties** on the table toolbar.
2. Select the **Font** tab.
3. Format the font, as well as the font style and size.
4. Click **OK**.

Changing units and number format

1. Click **Table properties** on the table toolbar.
2. Select the **Units** tab, and then select the plot you want to format from the **select plot** drop list.
3. Choose the prefix option you want.
4. Select the desired number of decimal places.
5. To display numbers in scientific format, check the **Scientific** check box.
6. Click **OK**.

4. Add a Table to the Project

MultiLab displays new data in the table window every time you start a new recording. You can always display previously recorded data using the **Edit table** dialog**.** If you want to save a table that you created to your project, or to update a saved table with changes you made, use the **Add to project** tool:

Click **Add to project** on the table toolbar.

3.4.4. Meters

MultiLab enables you to view data in meters format on the screen (one meter for each sensor), with up to four meters showing at once. The meters can display live data while MultiLab is recording, or saved data when a saved file is replayed.

When a cursor is displayed, the meter shows the measured values that correspond to the time of the point at which the cursor is positioned.

There are three meter types: analog, bar and digital. The meter's scaling automatically matches the graph's scaling.

To set up the meters:

1. Click **Meter Setup** on the main toolbar:
2. Select the meter type, and the data set to be displayed.
3. A list entry that begins with a graph number denotes a displayed data set. A list entry that begins with an input number denotes the next recording, and will be displayed on the meter the next time you start a recording.
4. Repeat this procedure for up to four meters.
5. To remove the meters click **Meter Setup** , and click **Remove all**.

3.4.5. Data Map

Click **Data Map** to display or remove the Data Map.

The data map is a separate window that displays the list of data sets that were recorded or downloaded in the current session, as well as the lists of all the saved graphs and tables. Use the Data Map to navigate through the available data sets and to keep track of the data that is displayed in the graph window.

1. Control the Display with the Data Map

The items in the Data Map are sorted into three main categories:

- Data sets (including analysis functions)
- Saved graphs
- Saved tables

Double click on a category to bring up the full list. Double click a second time to collapse the list. You can also use the plus (+) and minus (-) signs next to the icons to expand or collapse the categories.

The Data sets list expands to sub-categories of experiments and functions. To display the complete list of measurements, or the complete list of analysis functions performed on the measurements for any individual experiment, double click the experiment's icon or click the plus sign (+) next to it.

To collapse a list under an individual experiment, double click the experiment's icon or click the minus sign (-) next to it.

To display a data set or a saved graph in the graph window, or to display a table in the table window, double click its icon. Double click a second time to remove it.

You can also use a shortcut menu to display or remove a data set from the graph. Simply right-click an icon, then click **display on graph #1** or **display on graph #2.**

To delete an individual item from the Data Map and from the project, right-click on its icon and click **Delete**. To permanently delete the item, click **Save** on the main toolbar.

To remove all data sets from the Data Map, right-click the Data sets icon and click **Clear All Data**.

2. Understanding Data Map Icons

- Data sets list
  - Functions – includes all the analysis functions of the project
    - Individual function – Currently not on display
    - Individual function – Currently displayed on graph 1
    - Individual function – Currently displayed on graph 2
    - Individual function – Currently displayed both on graphs 1 and 2
    - Function
  - Experiment – Includes all recorded data of the experiment
    - Individual data set – Currently not on display
    - Individual data set – Currently displayed on graph 1
    - Individual data set – Currently displayed on graph 2
    - Individual data set – Currently displayed both on graphs 1 and 2
    - Data recorded without video
    - Data recorded with video
- List of saved graphs
  - Saved graph – Data sets vs. time
  - Saved graph – Data sets vs. data set
    - Graph currently not on display
    - Graph currently displayed on graph 1
    - Graph currently displayed on graph 2
    - Graph currently displayed both on graphs 1 and 2
- List of saved tables
  - Saved table
    - Table not currently displayed
    - Table currently displayed

3.4.6. Export Data to Excel

Click **Export to Excel** on the graph toolbar to export the displayed data to Excel. You will be given the option of saving the data in a specific location, and then MultiLab will open a new Excel workbook displaying the data.

1. Export File Settings

If MultiLab fails to export the data properly, try to change the export file settings:

1. Click **File** on the menu bar, and then click **Export file settings**.
2. Check the **Ignore regional settings** check box.
3. Click **OK**.

3.4.7. Copy the Graph as a Picture

You can copy the graph to the clipboard as a picture and then paste it to other Windows programs such as Word or PowerPoint:

1. In the Graph menu, click **Copy graph**.
2. Open the destination file.
3. In the destination file, right click and select **Paste**.

3.5. Programming the Data Logger

3.5.1. Setup

1. Quick Setup

Use the Setup wizard to guide you through the setup process.

1. Click the **Setup wizard** icon on the main toolbar to launch the setup process for the data logger. The USBLink Setup icon is . The MultiLogPRO Setup icon is .

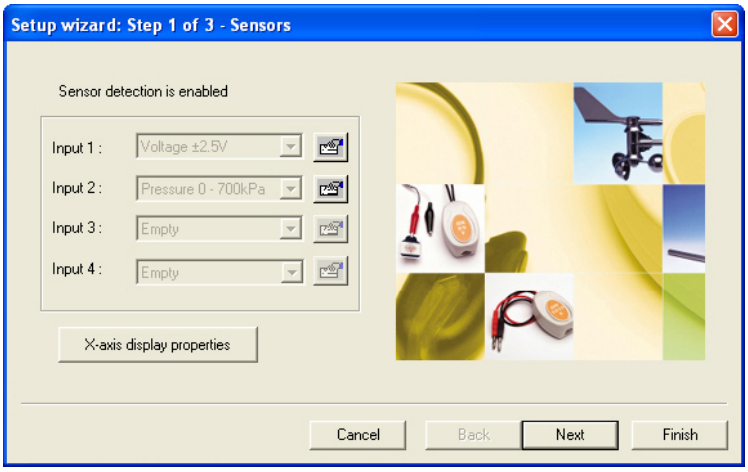


Figure 12: Setup wizard step 1 of 3

The first step is to assign sensors to each input. If you are working with the data logger in Auto ID mode, the sensors are selected automatically as you plug them in to the data logger. Otherwise, you can manually select the sensors you are using from the corresponding input drop down menus.

2. Click **Next** to move to the second step:

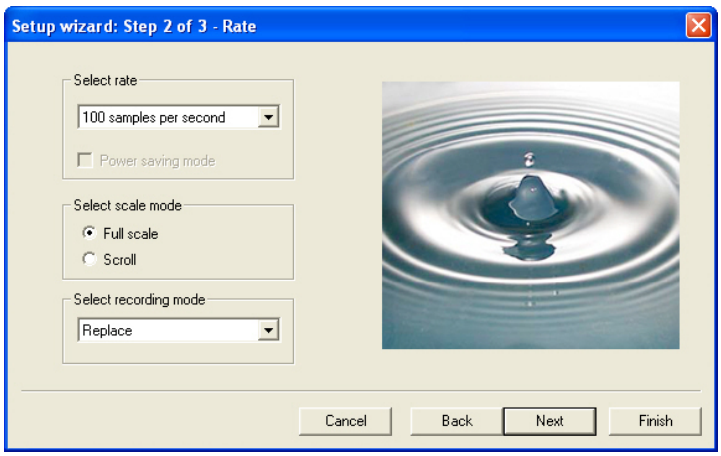


Figure 13: Setup wizard step 2 of 3

3. Select the desired recording rate in the **Select rate** drop down menu.

4. Select the **Scroll** option if you want the graph window to scroll as the data recording progresses.

5. Select the desired data recording mode in the **Select recording mode** drop down menu.

6. Click **Next** to move to the third step:

Figure 14: Setup wizard step 3 of 3

7. Select the desired length of the recording period in the **Select recording time** drop down menu.
   The recording period is displayed as a unit of time by default. To display the recording period as the number of recording samples, select the **By samples** option. The number of samples is calculated with the following formula:

   Total recording samples = Recording rate x Recording period

8. To start the data recording only when a specific time or measurement condition has been met click **Triggering** to open the triggering dialog box (see page 68).

9. Click **Finish** to complete the setup and to send the setup command to the data logger.

2. Defining Sensor Properties

Some of the sensors can produce more than one measurement. For example, the distance sensor measures distance, but MultiLab also calculates the velocity and acceleration of the measured body in real-time. MultiLab automatically displays the basic measurement of distance, but enables you to display any combination of distance, velocity and acceleration. Other sensors may only give one measurement, but can display the data in different units. For example, the acceleration sensor can display the acceleration in multiples of the gravity acceleration, or in the standard unit m/s^2.

The Distance and Force sensors properties include definition of the positive direction and the distance sensor properties enable online averaging as this sensor is comparatively noisy.

You can define the properties of each sensor individually in the first step of the Setup wizard**,** or by selecting **Calibrate sensors** from the **Logger** menu.

1. Click **Setup Wizard** on the main toolbar to open the Setup wizard
2. Click **Properties** next to the input you want to set.
3. Click the check boxes next to the desired measurements.
4. To change more properties, click the corresponding tab at the top of the dialog box.
5. Click **OK**.

3. Setting the Zero Point of a Sensor

MultiLab enables you to rescale some sensors and to set the current readings to zero for subsequent loggings. This feature applies to the following sensors:

- Distance
- Force
- Magnetic field
- Light sensors
- Pressure sensors

To set the current readings of a sensor to zero:

1. Click **Setup Wizard** on the main toolbar to open the Setup Wizard.
2. Click **Properties** next to the input you want to set.
3. Click the **Set Zero** tab.
4. Check the **Set the current reading to zero** checkbox.
5. Click **OK**.
6. Click **Finish**

MultiLab takes a single measurement and set the reading to zero.

To change the zero point:

1. Click **Setup Wizard** on the main toolbar to open the Setup Wizard.
2. Click **Properties** next to the input you want to set.
3. Click the **Set Zero** tab.
4. Click **Reset zero**.

5. Click **OK**.
6. Click **Finish**.

To return to the default zero point:

1. Click **Setup Wizard** on the main toolbar to open the Setup Wizard.
2. Click **Properties** next to the input you want to set.
3. Click the **Set Zero** tab.
4. Uncheck the **Set the current reading to zero** checkbox.
5. Click **OK**.
6. Click **Finish**.

4. Presetting the Display

You may want to define the graph's settings, such as formatting and scaling the graph and selecting the axes, and to define the meters' settings prior to beginning a recording session. You can define the settings of each sensor input individually in the first step of the **Setup Wizard**:

1. Click **Setup Wizard** on the main toolbar to open the Setup Wizard.
2. Click **Properties** next to the input you want to set.
3. Click the **Display properties** tab.
4. Select a measurement from the **Select measurement** drop down menu.
5. Select the graph or graphs in which you would like to display the data, from the **Display on graph** drop down menu.
6. Select a meter in the **Meter type** drop list if you want to display the data in a meter as well as on the graph.
7. Format the line and markers in the **Plot** section.
8. If you want a specific scale, uncheck the **Auto scale** checkbox and enter the desired minimum and maximum values of the axis.
9. Click **OK**.

5. Presetting the Graph's X-axis

1. Click **X-Axis display properties** in the first step of the Setup Wizard to open the dialog box:

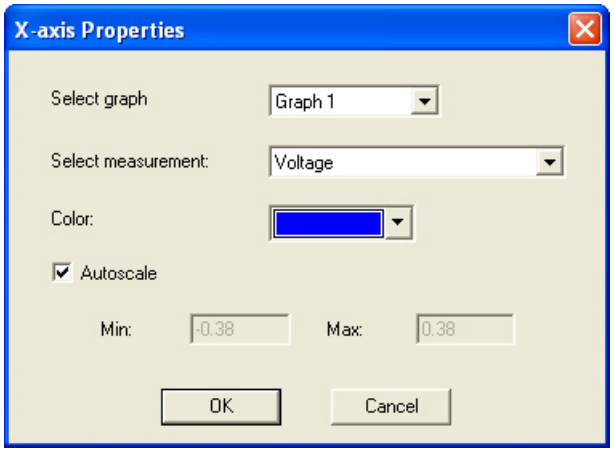


Figure 15: X-axis properties dialog box

2. Select the graph you wish to modify.
3. Select the measurement you'd like to display on the X-axis.
4. If you want a specific scale, uncheck the **Auto scale** check box and enter the minimum and maximum values of the axis.
5. Click **OK**.

6. Triggering

To start the data recording only when a specific time or measurement condition has been met, click **Triggering** in step 3 of the Setup Wizard to open the triggering dialog box:

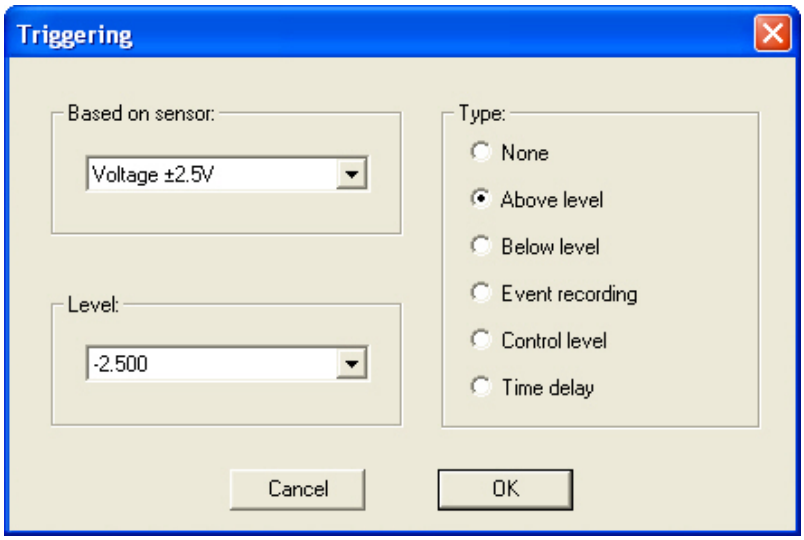


Figure 16: Triggering dialog box

1. Select the triggering sensor in the **Based on sensor** drop down menu.
2. Choose one of the following from the **Type** options:

    a) **None** - Trigger is disabled

b) **Above level** - Start logging only once the measured value is ***higher*** than the trigger level.

c) **Below level** - Start logging only once the measured value is ***lower*** than the trigger level.

d) **Event Recording** - This function enables you to record the exact time and date at which a certain phenomenon occurs: The trigger level set for this option is actually a threshold setting. Each time the threshold is crossed, the data logger will record the exact time and date of the occurrence, and will continue to do so until the desired number of samples has been obtained.

Note: The trigger acts on analog measurements only (not on the Distance sensor). The trigger condition must be fulfilled for at least 300 μS.

e) **Control Level** - The Control Level trigger allows you to create an automatic sense & control system. This means that you can connect a sensor measuring a certain phenomenon (for example, temperature) and connect a device that will start operating when the recorded data from the sensor falls above or below a certain level (for example, a fan that will start operating when the temperature measured by the sensor rises above 30 °C). This function requires the use of a Splitter cable and a Control sensor. The cable divides each input into a sensor cable and a controller cable. After setting the control level and starting the data logging process, the sensor will sample and record the data as usual. However, when the measurement from the sensor rises above the predetermined threshold value, the controller cable will send a pulse of 5 V to the Control sensor, and will continue to do so until the sensor measures a value below the threshold level. When receiving the 5 V pulse, the Control sensor will close/open a relay capable of switching 110/220 V to any load.

f) **Time delay** - This trigger type enables you to set a timer that will start the logging after a predetermined amount of time. After setting the trigger to **Timer Delay**, click the down arrow on the **Level** combo-box, and select from the 17 different time options. The timer will start its countdown when you click **RUN**, and the actual recording will start once the countdown has ended.

3. Select the trigger level in the **Level** drop down menu.

4. Click **OK**.

Note: When you turn off the MultiLogPRO, it will save the setup for the next session.

3.5.2. *Start Recording*

Click **Run** on the main toolbar. Click the **down arrow** to change the recording mode.

3.5.3. *Stop Recording*

Click **Stop** on the main toolbar.

3.5.4. *Clear USBLink's Memory*

This function is not relevant for the USBLink as it doesn't have onboard memory.

3.5.5. *Clear MultiLogPRO's Memory*

To erase all experiment data currently stored in the MultiLogPRO, click **Clear memory** in the **Logger** menu.

3.5.6. *Edit MultiLogPRO's Experiment Notes*

1. Connect MultiLogPRO to the PC.
2. Select **Edit notes** from the **Logger** menu to open the **Notes** dialog box with the MultiLogPRO's current experiment's notes downloaded to the window.

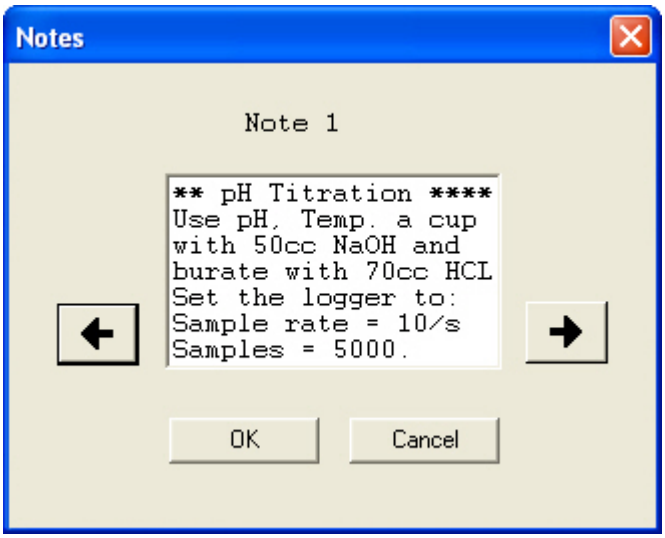


Figure 17: Edit experiment notes dialog box

3. From this dialog box, you can edit, delete, or write new notes.

Note: An experiment note is limited to 140 characters and a maximum of 5 notes can be stored in MultiLogPRO at any time.

4. Use the arrow buttons to move to the next note, or to the previous one.
5. Click **OK** to upload the edited notes to MultiLogPRO.

3.5.7. Calibrating the Sensors

MultiLab enables you to calibrate any of the sensors manually. This calibration is much more accurate than the calibration performed by USBLink or MultiLogPRO. With MultiLab, you can calibrate the sensor using two points instead of the *one point automatic offset calibration* used by the data logger:

1. Connect the data logger to the PC.
2. Select the **Calibrate sensors** option from the **Logger** menu.
3. Choose a sensor from the **Select sensor** drop down menu and click **OK**.
4. Click the **Calibration** tab.
5. Enter a distinct real value in each of the **Real Value** edit boxes and the corresponding measured values in each of the **Measured Value** edit boxes (The measured values are the values displayed by MultiLab when measuring the two real values).
6. Click **OK**.

The calibrated sensor parameters will be saved, so there is no need to calibrate the data logger every time you run the MultiLab program.

To reset to the default calibration for any sensor, select the sensor and click **Restore defaults**.

3.5.8. Define a Custom Sensor

Ordinarily, you will not need to use this option, but MultiLab enables the user to define additional custom sensors. This is a useful tool for when the data logger is communicating with many sensors from different vendors. See section 6.3 on page 134 for a list of supported sensors.

Any additional sensor that you would like to connect to USBLink or MultiLogPRO must comply with the following restrictions:

- The sensor's output must be greater than or equal to **0V** and less than or equal to **5V**. Remember that all sensors transform actual data into electrical data, so the electrical output should remain between 0 and 5 V.
- The sensor Transfer Function (sensor output voltage changes vs. the sampled phenomenon changes) must be a linear Transfer Function.
- The sensor must have a code resistor in order to be automatically identified. If the sensor does not have a code resistor, you will have to work in **8 inputs** mode and select the sensor manually.

  To determine whether your sensor has a code resistor or not, simply plug it in to the data logger (while in **Auto ID** mode) and see if MultiLogPRO displays the setup menu and the sensor name.

  Refer to the appendix to learn how to add a code resistor to your custom sensor.

  To define a new sensor:

  1. Connect the data logger to the PC.
  2. Select **Define new sensor** from the **Logger** menu to open the **Define new sensor** dialog box:

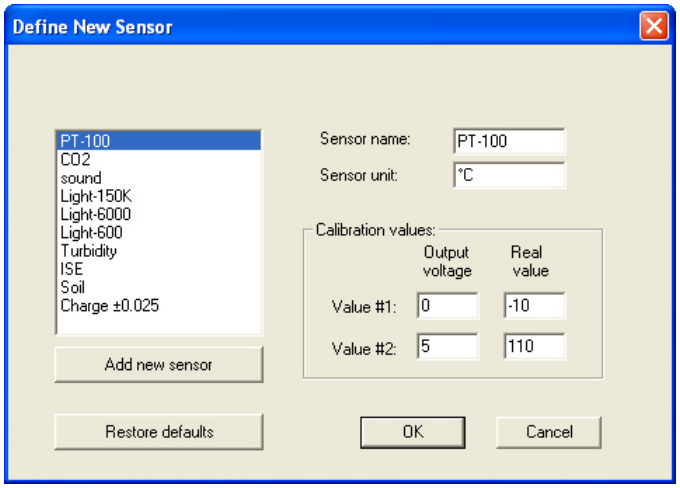


Figure 18: Define new sensor dialog box

3. Click **Add New Sensor**.
4. Type a sensor name and a sensor unit into the relevant fields.
5. Type in two calibration values (two real values and the corresponding output voltages of the sensor).
6. Click **OK**.

3.5.9. Communication Setup

USBLink communicates with the MultiLab software via a USB port and the MultiLogPRO communicates via a USB or Serial communication port. Some users may find it difficult to select the correct port, in which case MultiLab can perform an automatic port selection, and can also report on the status of all available ports.

Automatic COM Port recognition

The computer may have several communication ports. One of these ports is usually available for external communication. It is not necessary to know which port is available, since **MultiLab will find it for you**:

1. Connect the communication cable from the data logger to one of the computer COM port connectors.
2. Turn on the data logger and launch the MultiLab software.

MultiLab automatically attempts to communicate with the data logger. Once communication is established, MultiLab reports the connection in the status bar at the bottom of the application window.

If communication fails:

Working in Windows OS

1. Select **Comm Setup** from the **Logger** menu. MultiLab will display a dialog box reporting what COM ports are already in use, and which port is recommended for use with the USBLink or MultiLogPRO:

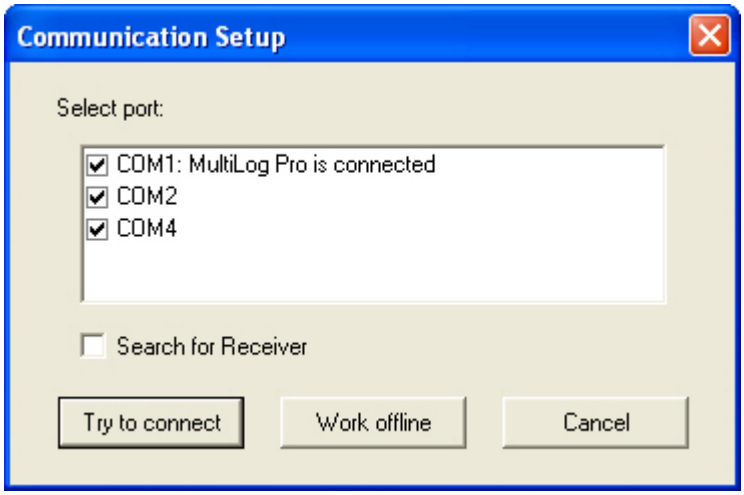


Figure 19: Communication setup dialog box (Windows)

2. Click **Try to connect** and MultiLab will try to communicate with the logger. If communication is achieved, MultiLab will designate the selected port as the specific logger's communication port.

You can override the MultiLab recommendation and choose the COM port yourself by clicking the checkbox button to the left of the desired port, and clicking **Try to connect**.

Note: In the event of any communication malfunction, please refer to 4.1: Troubleshooting Guide.

3. You can click **Work offline** if you wish to work without the logger. While working offline, you can still open saved files to view and analyze them.

Working in Mac OS

1. Select **Comm Setup** from the **Logger** menu. MultiLab will display a dialog box listing the available ports:

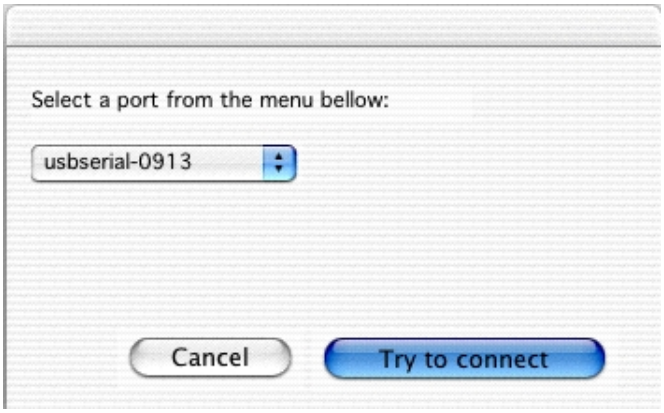


Figure 20: Communication setup dialog box (Mac OS)

2. Select a port from the drop down menu.

3. Click **Try to connect** and MultiLab will try to communicate with the data logger. Once communication is established, MultiLab reports the connection in the status bar at the bottom of the application window.

4. Click **Cancel** if you wish to work without the data logger. While working offline, you can still open saved files to view and analyze them.

Note: MultiLab for MAC does not support the USBLink at this time.

3.6. Analyzing the Data

3.6.1. Reading Data Point Coordinates

Position the cursor (see page 54) on a point to display its coordinates on the information bar at the bottom of the graph window.

If more than one curve is displayed, and you want to read the Y- coordinates of all of the curves simultaneously, bring up digital meters (see page 61) for each of the curves. When you position a cursor on one curve, the meters will show the corresponding Y-coordinates for the other curves.

3.6.2. Reading the Difference between two Coordinate Values

Position one cursor on the first point and a second cursor on the second point to display the difference between the two coordinate values on the information bar at the bottom of the graph window.

3.6.3. Working with the Analysis Tools

The analysis tools can only be applied to data sets that are displayed in the graph window.

1. Use the cursors (see page 54) to select the graph and the data range to which you want to apply the analysis.
2. Select the analysis function you wish to use.

The analysis function will be added onto the graph, with the exception of the smoothing (averaging) function, which will replace the original data set.

To measure and analyze time events with photogates use the Timing Wizard (see page 98).

3.6.4. Smoothing

The smoothing tool is very useful in reducing random noises, especially if you want to apply any analysis functions to the data. The smoothing process replaces every data point with the average of its neighboring points.

1. Use the cursor to select the graph that you want to smooth.
2. Click **More smoothing** on the graph toolbar.
3. You can repeat the procedure to further smooth the data.
4. Click **Less smoothing** to reduce the amount of smoothing.

3.6.5. Statistics

Use the statistics tool to display statistics of a selected data set or a range of data.
The statistics include:

Average	The average of all the numbers in the range
Median	The median is the number in the middle of a set of numbers; that is, half the numbers have values that are greater than the median, and half have values that are less. If there is an even number of numbers in the set, then Median calculates the average of the two numbers in the middle
StDev.	The standard deviation
Minimum	The smallest value in the range
Maximum	The largest value in the range
Sum	Adds all the numbers in the range
Area	The area between the graph and the x-axis in the range
Samples	The number of data points in the range
Rate	The recording rate

To display statistics:

1. Use the cursors to select the graph and the data range to which you want to apply the statistics.
2. Click **Analysis** on the menu bar, and then click **Statistics**.

   MultiLab will open a statistics window and will display the results in it.

3.6.6. Most Common Analysis Functions

1. Linear Fit

Click **Linear Fit** on the main toolbar to draw a line of linear least square fit

$$y = ax + b$$

and to display the line's equation.

Note: If you want the automatic curve fit equation to start at $t = 0$, apply the crop tool before applying the linear fit (see page 98).

2. Derivative

Click **Derivative** on the main toolbar to construct a graph in which each point is the slope of the three consecutive points on the source graph.

3. Integral

Choose **Integral** from the **Analysis** menu to construct a graph in which each point is the integral of all the preceding points on the source graph.

3.6.7. The Analysis Wizard

1. Using the Analysis Wizard

The analysis wizard will guide you through the various analysis functions available in the MultiLab program. The analysis functions are grouped into three main categories: curve fit (regression), averaging, and mathematical and trigonometric functions.

To apply an analysis function to a data set:

1. Use the cursors to select the graph or data range to which you would like to apply the analysis (optional – you can select the desired data set directly from the Analysis Wizard).
2. Click **Analysis Wizard** on the main toolbar.
3. Click a category tab:
    a) Curve fit
    b) Averaging
    c) Functions

2. Curve Fit

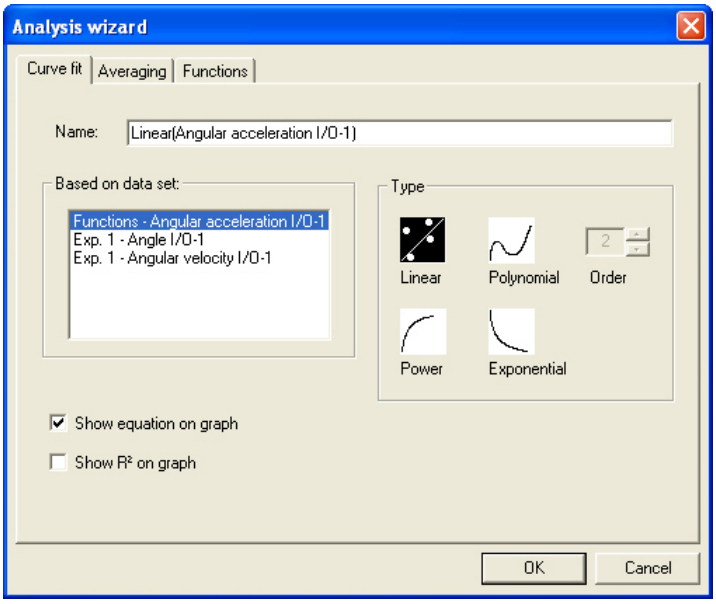


Figure 21: Analysis wizard – curve fit

1. Select a fit type by clicking its icon (If you choose polynomial fit, select the order you want).

2. If you use the cursor to select a data set, it will be highlighted in the **Based on data set** list, but you have the option of selecting a different data set.

3. Type a name in the **Name** box (optional - the default name includes both the function and the data set names).

4. Click the **Show equation on graph** check box to display the line's equation on the information bar.

5. Click the **Show R^2 on graph** check box to display the correlation coefficient on the information bar.

6. Click **OK**.

Note: If you want the automatic curve fit equation to start at $t = 0$, apply the crop tool before any type of curve fitting (see page 98).

3. Averaging

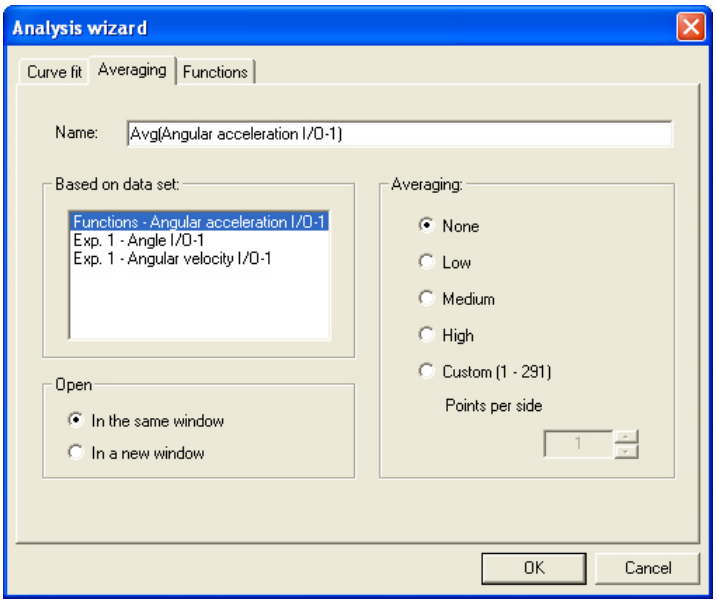


Figure 22: Analysis wizard – averaging

1. If you use the cursor to select a data set, it will be highlighted in the **Based on data set** list, but you have the option of selecting a different data set.

2. Select an averaging option (if you choose custom averaging, choose the number of averaging points in the **Points** box).

3. Enter a name in the **Name** box (optional - the default name include both the function and the data set names).

4. Select an **Open** option.

5. Click **OK**.

4. Functions

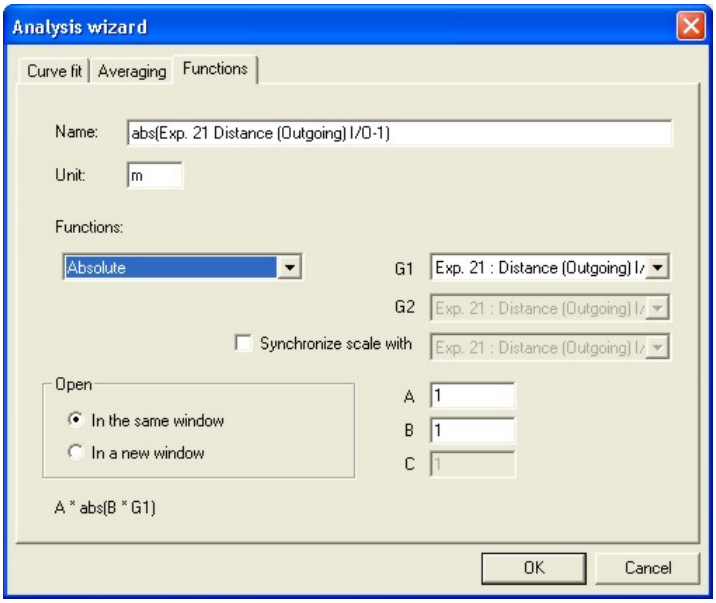


Figure 23: Analysis wizard – functions

1. Select a function from the **Functions** list. MultiLab displays the function's formula at the bottom of the dialog box.
2. If you use the cursor to select a data set, it will be highlighted in the **G1** drop down menu, but you have the option of selecting a different data set.

Tip: To create a function whose independent variable is time (e.g. to fit a mathematical function to a data series), select a time series from the **G1** drop down menu. If there are several plots on the graph the list includes a separate time series for each plot as the number of data point may vary from plot to plot.

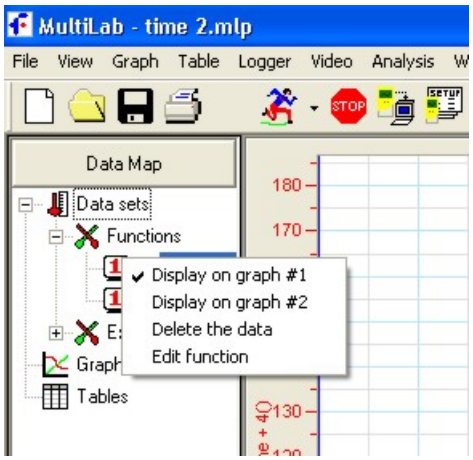
3. If the analysis function involves two data sets, select the second data or time series set from the **G2** drop down menu.
4. To synchronize the Y – Scale with one of the plots on the graph, check the **Synchronize scale with** checkbox and select the appropriate plot from the adjacent drop down menu.
5. Enter a constant in each of the **A, B** and **C** boxes (optional, the default values are one for a coefficient and zero for a free term).
6. Enter a name in the **Name** box (optional – the default name includes both the function's formula and the data set name).
7. Enter a unit (optional).
8. Select an **Open** option.
9. Click **OK**.

5. Editing a Function

MultiLab enables you to edit the functions parameters as well as its name and units after you have displayed it on the graph. The **Edit function** command is enabled for all the analysis functions created in the current session and is disabled when you open a stored file.

To edit the function:

1. Right click the function's icon in the Data Map to open a context menu.



2. Click **Edit function to** open the Function dialog.
3. Enter the new parameters.
4. Click **OK**.

3.6.8. Available Analysis Tools

This section includes a brief description of each of MultiLab's analysis functions.

For time, velocity and acceleration analysis see also the Timing Wizard on page 98.

1. Curve Fit

Linear $y = ax + b$

Draws a line of linear least square fit.

Polynomial $y = a_0 x^n + a_1 x^{n-1} + \cdots + a_n$

Draws a line of polynomial least square fit (you must select an order between 1 and 6.)

Power $y = \frac{a}{x^n}$

Draws a line of power least square fit.

Exponential $y = ae^{bx}$

Draws a line of exponential least square fit.

MultiLab displays the curve fit equation and the correlation coefficient (R^2) on the information bar below the graph.

2. Averaging

The average function replaces every point with the average of *n* neighboring points from both sides of the point.

Low averaging: $n = 5$, Medium averaging: $n = 11$, High averaging: $n = 41$.

3. Functions

In the formulas below, G_1 and G_2 represent selected data sets or time series, and A, B and C are constants that you can enter.

Absolute $y = A|BG_1|$

Draws a line of the absolute values of a data set.

Add $y = AG_1 + BG_2$

Draws a line of the addition of two data sets.

Arccosine $y = A\arccos(BG_1)$

Draws a line of the arccosine values of a data set (in radians). Arccosine is the angle whose cosine is BG_1. The argument BG_1 must be between –1 and 1.

Arcsine $y = A\arcsin(BG_1)$

Draws a line of the arcsine values of a data set in radians. Arcsine is the angle whose sine is BG_1. The argument BG_1 must be between –1 and 1.

Cosine $y = A\cos(BG_1 + C)$

Draws a line of the cosine values of a data set. The argument $BG_1 + C$ must be expressed in radians.

Delta Y $y = G_1 - G_1(t = 0)$

Draws a line of the difference between the Y-coordinate of every point and Y-coordinate of the first point. Use this function to move the data set along the Y-axis so that the point will intersect the Y- axis at the origin.

Derivative $y_n = \frac{y_{n+1} - y_{n-1}}{2\Delta t}, \Delta t = \frac{1}{sampling\ rate}$

Draws a line of the slopes of every three consecutive points of a data set. For high recording rates and small Δt, this line may be very noisy, which is why smoothing the data set is recommended before applying the derivative function.

Divide $y = \frac{AG_1}{BG_2}$

Draws a line of the division of two data sets

Envelope (lower) Lower envelope of G_1 with tolerance of A points

Draws a line that connects the minimum values of a data set. The tolerance defines the minimum distance (in sampling points) between two minima, so that the envelope function is able to ignore random noises.

Envelope (upper) Upper envelope of G_1 with tolerance of A points

Draws a line that connects the maximum values of a data set. The tolerance defines the minimum distance (in sampling points) between two maxima, so that the envelope function will be able to ignore random noises.

Exp. $y = Ae^{BG_1} + C$

Draws a line of e raised to the power of a data set.

Fourier transform Discrete Fourier transform of G_1.

Draws a line of the amplitudes of the harmonics of Fourier transform vs. frequency.

Frequency The frequency of G1 (minimum of A points in one cycle).

Draws a line of the frequency of a periodic data set vs. time. The constant A defines the minimum data points in one cycle.

Integral $y = A + B\sum G_1 \Delta t$

Draws a line in which each point is the discrete integral of all the preceding points in a data set.

Kinetic energy $y = \frac{1}{2} A(G_1)^2$

Draws a line of the kinetic energy of a data set. The argument G_1 must be the velocity of the body, and the constant C_1 must be the mass of the body.

Linear $y = AG_1 + B$

Draws a line of a linear displacement of a data set. This function is useful when you want to change the point of origin of a data set.

Ln $y = A\ln(BG_1)$

Draws a line of the natural logarithm of a data set. The argument BG_1 must be positive.

Log $y = A\log_{10}(BG_1)$

Draws a line of the logarithm of a data set to base 10. The argument BG_1 must be positive.

Multiply $y = AG_1 \cdot BG_2$

Draws a line of the multiplication of two data sets

Quadratic $y = AG_1^{\,2} + BG_1 + C$

Draws a line of the quadratic form of a data set.

Reciprocal (1/X) $y = \frac{A}{G_1 + B} + C$

Draws a line of the reciprocal values of a data set.

Sine $y = A\sin(BG_1 + C)$

Draws a line of the sine values of a data set. The argument $BG_1 + C$ must be expressed in radians.

Square (X^2) $y = A(BG_1)^2$

Draws a line of the squares of a data set.

Square root $y = A\sqrt{BG_1 + C}$

Draws a line of the square root values of a data set: The argument C_2G_1 must be greater than or equal to zero.

Subtract $y = AG_1 - BG_2$

Draws a line the subtraction of two data sets.

Tan $y = A\tan(BG_1 + C)$

Draws a line of the tangent values of a data set. The argument $BG_1 + C$ must be expressed in radians.

3.6.9. Online Analysis

MultiLab enables you to analyze data from a live experiment and to display the analysis function in the graph window, as the data is being recorded and processed.

To execute online analysis, you will first have to use the Analysis Wizard to define the function to be used, and then edit the graph in order to display the function (see page 56).

For example, here is how to set up an online envelope (amplitude) function of data, recorded with a Voltage sensor connected to Input 1:

1. Click **Analysis Wizard** on the main toolbar to open the Analysis Wizard dialog box:

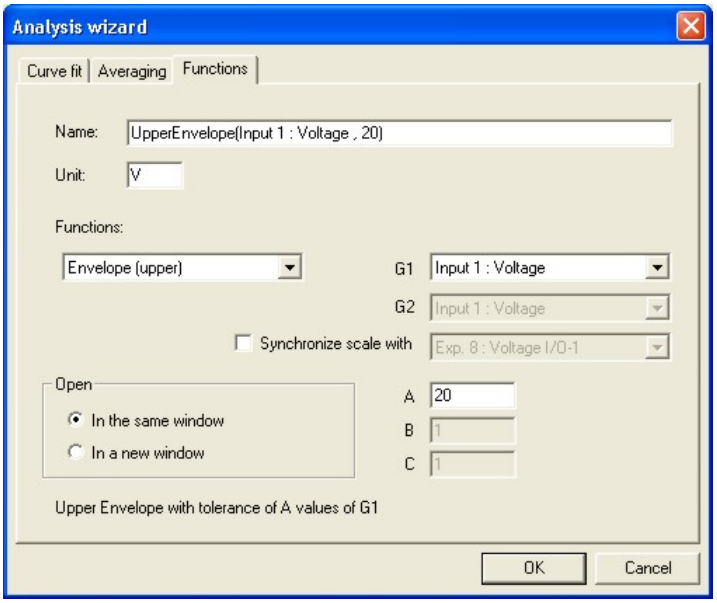


Figure 24: Analysis Wizard – online functions

2. Select **Envelope (upper**) from the **Functions** list.
3. Select **Input 1: Voltage** from the **G1** drop down menu.
4. Click **OK**.

5. Click **Edit graph** on the graph toolbar to open the Graph edit dialog box:

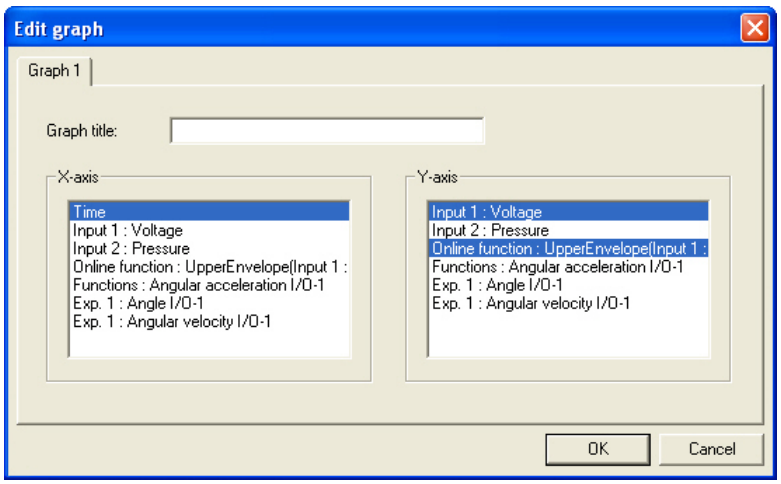


Figure 25: Using graph edit dialog to display online functions

6. In the **Y-Axis** list click **Input 1: Voltage** to select it and then click **Online function: Envelope (upper)** to select it.

7. If there are other highlighted data sets in the **Y-Axis** list, deselect them by clicking on them.

8. Click **OK**.

9. Click **Run** on the main toolbar to start recording. MultiLab will display the original data readings coming from Input 1, as well as the data processed by the analysis function:

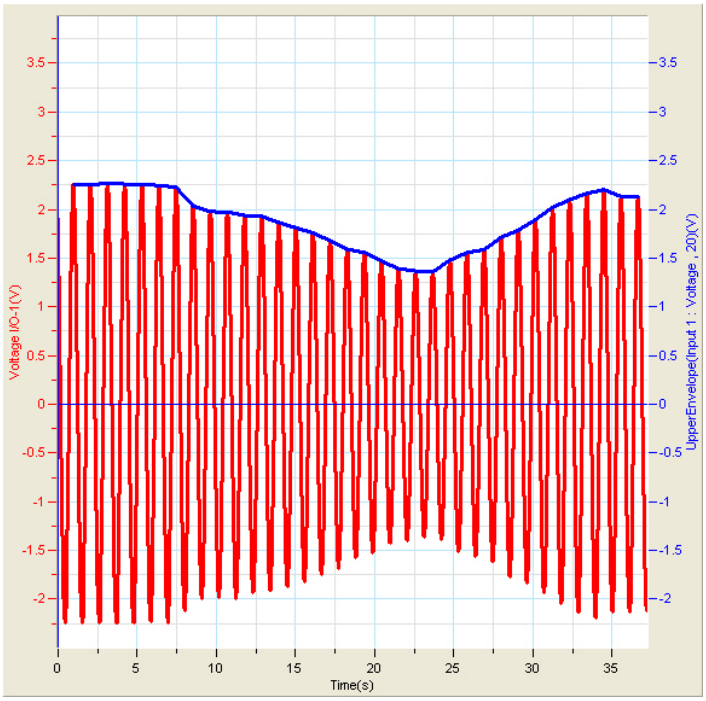


Figure 26: Online envelope function

The online analysis function will still be active in subsequent recordings.

To remove the online functions, click **Analysis** on the menu bar and then click **Clear online functions**.

3.6.10. Manual Curve Fitting

The manual curve fit tool enables you to draw a mathematical curve, to change the curve's parameters until it fits into data set, and to display the resulting equation. There are four types of mathematical curves you can draw:

Linear $y = At + B$

Draws a straight line.

Quadratic $y = A(t - B)^2 + C$

Draws a parabola.

Exponential $y = Ae^{Bt} + C$

Draws an exponential line.

Power $y = At^B + C$

Draws a line of the time raised to the power of a number from –5 to 5.

Note: If you want the curve fit equation to start at $t = 0$, apply the crop tool before any type of curve fitting (see page 98).

To apply manual curve fit:

1. Click on the **Analysis** menu, then click **Manual curve fit** to display the Manual curve fit dialog box.
2. To select a data set for display on the X-axis, click on the data set's name in the **X-axis** list.
3. To select a data set to display on the Y-axis, click on the data set's name in the **Y-axis** list.
4. Click **OK**. MultiLab will display the Manual curve fit toolbox at the bottom of the graph window:

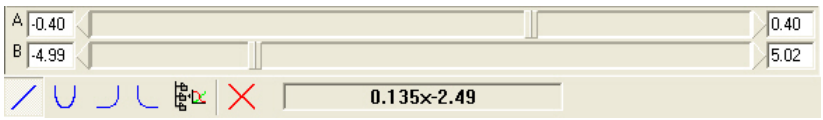


Figure 27: Manual curve fit toolbox

5. Choose one of the four curves by clicking its icon in the toolbox.

6. Use the sliders to change the A, B and C parameters until the new curve fits the sampled curve.

7. The lower and upper limits of each sliding bar are located on the sliding bar's left and right ends, respectively. You can change the limit values by clicking a limit box, and typing in your new value.

MultiLab will display the resulting equation on the information bar at the bottom of the toolbox.

8. Click **Add to project** in the toolbox to add the curve to the project.

9. To close the manual curve fit toolbox click **Exit** in the toolbox.

3.7. Video Motion Analyzer

3.7.1. Overview

MultiLab's Video Motion Analyzer enables you to capture position and time from video movies, convert this to data sets and analyze the data with all of MultiLab's analysis tools the same way you would analyze data from the data logger. You can capture one-body motion or two-body motion. You can select the origin and rotate the coordinate system.

With the Video Motion Analyzer you can also capture video movies either directly from video camera connected to the computer or from an external video source such as VCR.

3.7.2. Getting Started

1. Video Motion Analyzer Basics

Open the Video Motion Analyzer module

Click **Video Analysis** on the main toolbar

Open a movie from MultiLab's movie library or capture a new movie

Capture position and time

- **Scaling** – Scale the video to the real world dimensions
- **Coordinate system** – Set origin and axes direction
- **Step** – Set the number of frames you will capture position and time
- **Marking** – Mark the position of the body on the frames. MultiLab will automatically convert it to numerical data

Analyze the data

The captured data is automatically displayed in the graph and table windows. Analyze it as you would normally with MultiLab's projects.

2. Saving a New Movie

1. After you have finished capturing a new video movie click **Analyze movie** to begin capturing position and time.
2. MultiLab prompts to save the movie.
3. Type a name in the **File name** box and click **Save**.

3. Opening a Stored Movie

1. Click **Video Analysis** on the main toolbar.
2. Click **Open Movie** on the Video Motion Analyzer toolbar (lower toolbar).
3. Double click the movie you want to open.

4. Saving a Video Motion Analyzer Project

1. Click **Save** on the main toolbar.
2. Type a name in the **File name** box and click **Save**.

5. Opening a Video Motion Analyzer Project

1. Click **Video Analysis** on the main toolbar.
2. Click **Open** on the main toolbar.
3. Double click the Project you want to open.

3.7.3. Capturing a New Movie

There are two basic options for capturing video onto your computer from:

- A device attached to your computer
- An external source through a video capture board

1. From a Device Attached to your Computer

From a device attached to your computer (such as a Web cam), you can capture video directly from the camera to your computer. Web cams are intended primarily to

feed video over some connection (the Internet, for example). They generally produce lower video quality. With a Web cam, you can only record when the Web cam is attached to the computer. If quality and versatility are not your main concern, this may be the best solution for you.

To capture video from a Web cam:

1. Connect the Web cam to the computer.
2. Click **Video** on the menu bar, and then click **Enable video**.
3. Click **Video Analysis** on the main toolbar to open the Video Motion Analyzer module.
4. Click **Capture new movie** on the Video Motion Analyzer toolbar.
5. To begin recording click **Record** on the Capture new movie toolbar.
6. To finish recording click **Stop** .
7. Click **Analyze movie** to begin capturing position and time.
8. MultiLab prompts to save the movie before processing it.

2. From an External Source through a Video Board

Many video capture boards offer video-in/video-out features. A video capture card can be used with a wide variety of video sources and through a number of digital connections. Video from a VCR or video camera can be captured through video-out ports.

To capture video from a videotape through a VCR:

1. Insert the tape into the VCR. Go to the point you want to capture and then stop the tape.
2. Find the video-out on the back of the VCR and connect one end of the appropriate cable. Connect the other end of the cable to the video-in on your video capture board.
3. Click **Video** on the menu bar, and then click **Enable video.**
4. Click **Video Analysis** on the main toolbar to open the Video Motion Analyzer module.
5. Click **Capture new movie** on the Video Motion Analyzer toolbar.

6. To begin capturing click **Record** on the Capture new movie toolbar.
7. Play the video. Make sure that you start the video after you start the capture to make sure nothing gets cut off from the beginning.
8. To finish capturing stop the VCR and click **Stop** .
9. Click **Analyze movie** to begin capturing position and time.

   MultiLab prompts to save the movie before processing it.

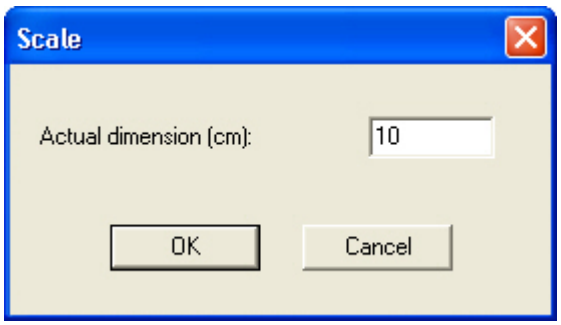
3.7.4. Capturing Position and Time

1. Scaling

In order to scale your project you must tell MultiLab the real world dimensions. When you film a new movie make sure to measure the dimension of a dominant object in the frame. Try to find an object that's dimensions are in the magnitude of the whole scene.

Scaling is done in two steps – you need to mark the object in the video frame and to type in the real dimensions:

1. Click **scale** on the Video Motion Analyzer toolbar to open the Scale dialog:



2. Click one end of the scaling object.
3. Click the body's other end.

   MultiLab will display two markers on the points you clicked.
4. You can drag the markers to change their position.
5. Type in the body's actual dimension in the **Actual dimension** edit box (in cm).
6. Click **OK.**

You can change the scaling anytime by clicking **Scale** and repeating the procedure.

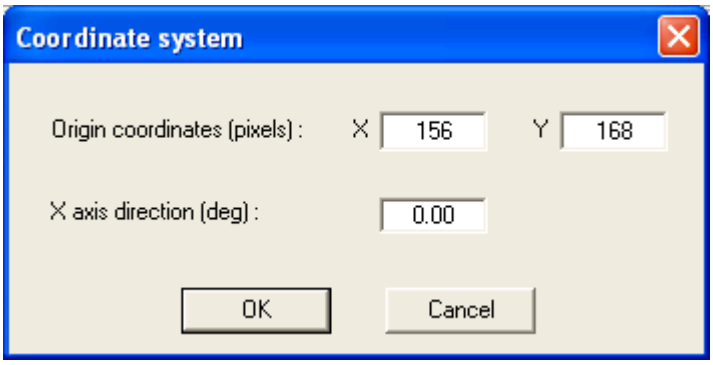
2. Set Coordinate System

To set the coordinate system you must specify the origin position and the x axis direction. You can do it either by a click of the mouse or by entering it manually to the coordinate system dialog.

Unless you specify otherwise MultiLab will use its default: the origin is in the lower left side of the frame and the axes are parallel to the window's sides.

Set origin

1. Click **Set origin** on the Video Motion Analyzer toolbar to open the Coordinate system dialog:



2. Click a point in the frame where you want the origin to be.

   MultiLab automatically updates the X and Y origin coordinates edit boxes and moves the axes on the frame to the new origin.

3. You can move the origin by clicking another point in the frame.

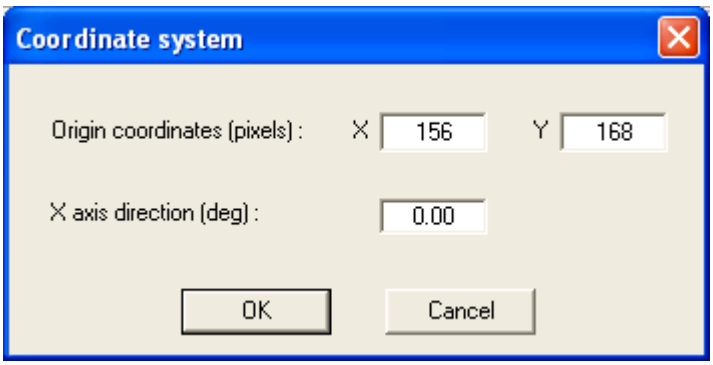
4. You can enter the origin coordinates manually by typing them in the corresponding edit boxes (in pixels).

5. You can type in the x axis direction (in degrees) in the **X axis direction** edit box.

6. Click **OK**.

Set X-axis direction

1. Click **Rotate origin** on the Video Motion Analyzer toolbar to open the Coordinate system dialog:



2. Click a point in the frame where you want the x axis to be placed.

MultiLab automatically updates the X axis direction edit box and rotates the axes on the frame to the new direction.

3. You can keep rotating the axes by clicking another point in the frame.
4. You can type in the x axis direction (in degrees) in the **X axis direction** edit box.
5. You can change the origin coordinates by typing them the X and Y origin coordinates edit boxes (in pixels).
6. Click **OK**.

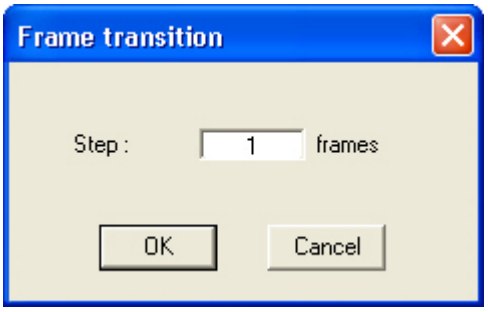
You can change the coordinate system origin and direction anytime by clicking **Set origin** or **Rotate origin** and repeating the procedure.

3. Set Step

In the marking process, MultiLab automatically steps the video to the next frame every time you click to add a marker.

To change the step to more then one frame at a time:

1. Click **Video analysis** on the menu bar and click **Frame transition** to open the Frame transition dialog:



2. In the **Step** edit box, type in the number of frames you want MultiLab to advance in one step.
3. Click **OK**.

4. Mark the Video

One-body motion

1. Click **Play** on the Video Motion Analyzer toolbar and observe the motion.
2. Decide what will be the **marking point** – the exact point on the moving object that you want to mark.

Tip: Try to choose a clear and sharp point that is visible throughout the entire movie

3. Click **Go to first** to roll the film back to the beginning.

4. Click **Next frame** until you reach the frame with which you want to start the capture.

5. Click the **marking point** on the moving object.

MultiLab automatically marks the point on the screen and creates two new data sets (one for x coordinates and one for y coordinates). It then adds the point's coordinates and time to the corresponding data sets and updates both the graph and the table, then automatically moves to the next frame.

Note: You don't see the mark because the display had already moved to the next frame.

6. Continue clicking the **marking point** on every frame until you capture all the data you need or until the video doesn't step anymore.

Observe that the graph and table are updated with each mouse click.

Note: In order for MultiLab to automatically move to the next step after one mouse click, the **Consecutive** option in two-body motion must be selected (the default option).

Two-body motion

Use the left mouse button to mark the first body and the right mouse button to mark the second body.

You can mark two-body motion in two ways: simultaneously or consecutively. In the simultaneous method you mark the two bodies alternately on every step of the marking process. In the consecutive method you finish marking the whole motion of the first body and then repeat the process with the second body.

Simultaneous marking

1. Click **Video Analysis** on the menu bar, point to **Two-body motion**, and then click **Simultaneous**.

2. Proceed as in one body motion except that in step 5 right click to mark the first body and left click to mark the second body.

   MultiLab waits for both right and left mouse clicks before moving to the next frame.

3. Keep clicking alternately with the right and left mouse button at every step.

Consecutive marking

1. Click **Video Analysis** on the menu bar, point to **Two-body motion**, and then click **Consecutive**.

2. Proceed as in one body motion until you finish marking the first body.

3. Click **Go to first** to roll the film back to the beginning.

4. Click **Next frame** until you see a marker on the first body.

5. Right click the second body to mark it.

6. Keep right clicking on every step to mark the second body's track.

Viewing markings

You can view the markings frame by frame. You can also view the markings on the video in parallel with the graph's cursor so that the marker and the cursor are synchronized.

To view just the markings:

Use the **Next frame** and **Previous frame** buttons on the Video Motion Analyzer toolbar to view the desired frame.

To view the markings in parallel with the cursor:

1. Display the cursor on the graph.

   MultiLab automatically displays the corresponding frame with the marker.

2. To scroll through the frames you can either use the **Next frame**

   and **Previous frame** buttons on the Video Motion Analyzer toolbar or drag the cursor on the graph or use the left and right arrow keys on the keyboard.

Editing the data

You can change the position of the marker at a specific frame. MultiLab will automatically update the corresponding point in the data set.

1. Display the frame you want to edit.
2. Click and drag the marker to the new position.

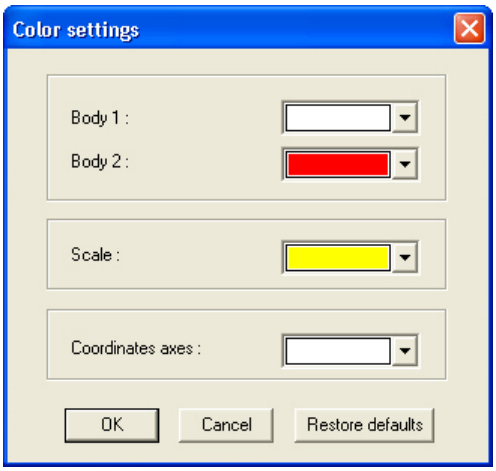
Erasing markings

You can erase a marker from a specific frame. MultiLab will automatically delete the corresponding point in the data set.

1. Display the frame you want to edit.
2. Click **Delete point** on the Video Motion Analyzer toolbar.
3. Click the marker.

5. Changing the Colors of the Marker and the Axes

1. Click **Color settings** on the Video Motion Analyzer toolbar to open a dialog:



2. Select the desired colors.
3. Click **OK**.

To restore default colors click **Restore defaults.**

3.7.5. Analyzing the Data

Once you have finished capturing position and time you can apply MultiLab's analysis tools to the data. MultiLab converts the body's track into two data sets X position (x coordinates) and Y position. By default the two data sets are displayed in the graph as a function of the time, but you can use the edit graph tool to display the track (Y vs. X).

In Video Motion Analyzer mode the video is usually displayed in the main window. To display the graph in the main window select **View selection** from the **View** menu.

Before applying analysis functions you may find it helpful to smooth the data with the smoothing tool on the graph toolbar.

At anytime you can change the origin and direction of the coordinates system

You can also change the coordinates of individual points by relocating them on the video frame.

3.8. Workbook

3.8.1. Working with Workbook

The Workbook is an online library of experiment manuals called *worksheets* that appear in the format of a Web page. Each worksheet includes an experiment template that automatically configures both MultiLab and the data logger at the push of a button. To begin recording, all you need to do is click **Run**.

Every time you run an experiment from a worksheet, MultiLab opens a new project file with the same predefined setup.

You can use Fourier-produced worksheets, or create your own. You can also modify Fourier's existing worksheets to meet your own specifications.

3.8.2. Opening a Worksheet

1. Click **Workbook** on the menu bar, and then click **Open worksheet**.
2. Navigate to the folder in which the worksheet is stored.
3. Double click the file name to open the worksheet.

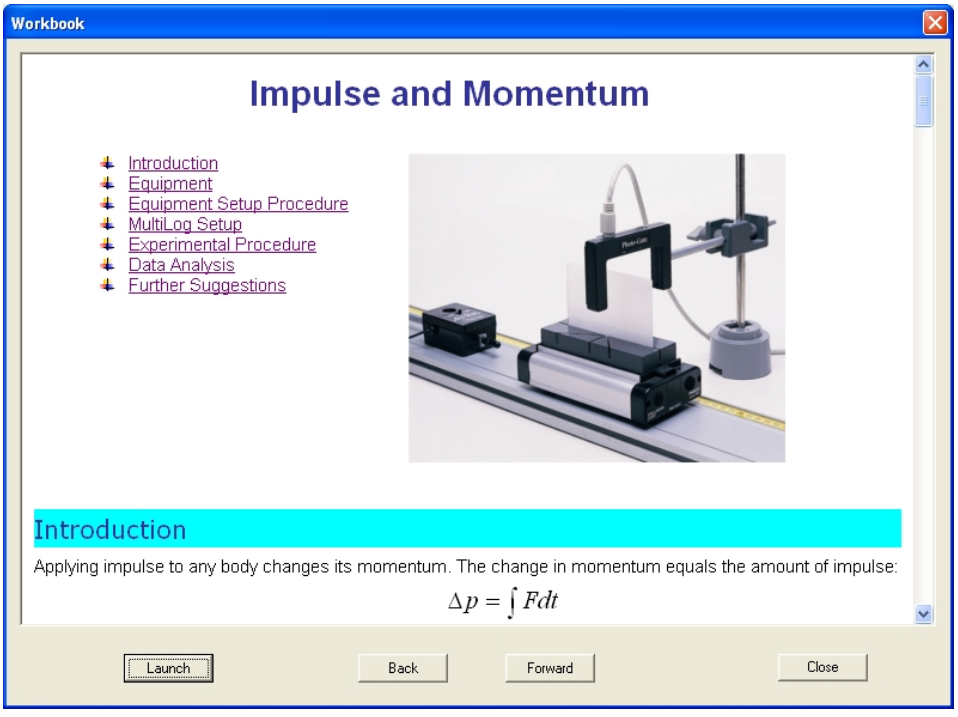


Figure 28: Worksheet

4. Follow the on-screen instructions and use the scroll bar, hyperlinks and the **Back** and **Forward** buttons to navigate throughout the document.
5. Click **Launch** to configure MultiLab and the data logger.
6. Click **Close** to return to MultiLab.

7. Click **Run** on the main toolbar to begin recording.

3.8.3. Create Your Own Worksheet

Creating a worksheet consist of two steps. First, create an HTML document using your HTML editor (For example, Word or Front Page). This file should include the Lab manual and the experiment instructions (see below). The second step is to use the MultiLab software to create a configuration file, which is a file that will store the specific settings you wish to define for the experiment. These include the USBLink or MultiLogPRO setup, MultiLab's layout, the recording mode, the graph format desired, special preset graph scaling, sensors measurement, etc.

1. Create an HTML Document with Word

Create a new Web page

1. Open Word.
2. In the **File** menu, click **New**.
3. Do one of the following:
   - On the **General** tab, click **Web Page** to open a blank Web page.
   - On the **Web Pages** tab, click the template that you would like to base your Web page on.
4. Enter your texts and pictures.
5. Click **Save** on the toolbar.
6. Navigate to C:\Program Files\Fourier Systems\MultiLab\Workbook.
7. Click **Save**.

Create a Web page from an existing Word document

1. Open the existing file with Word.
2. In the **File** menu, click **Save as Web Page**.
3. Navigate to C:\Program Files\Fourier Systems\MultiLab\Workbook.
4. Click **Save**.

2. Create a Configuration File

1. Open the MultiLab program.
2. Click **Workbook** on the menu bar, and then click **create new worksheet**.
3. Double click the file you want to configure to open it:

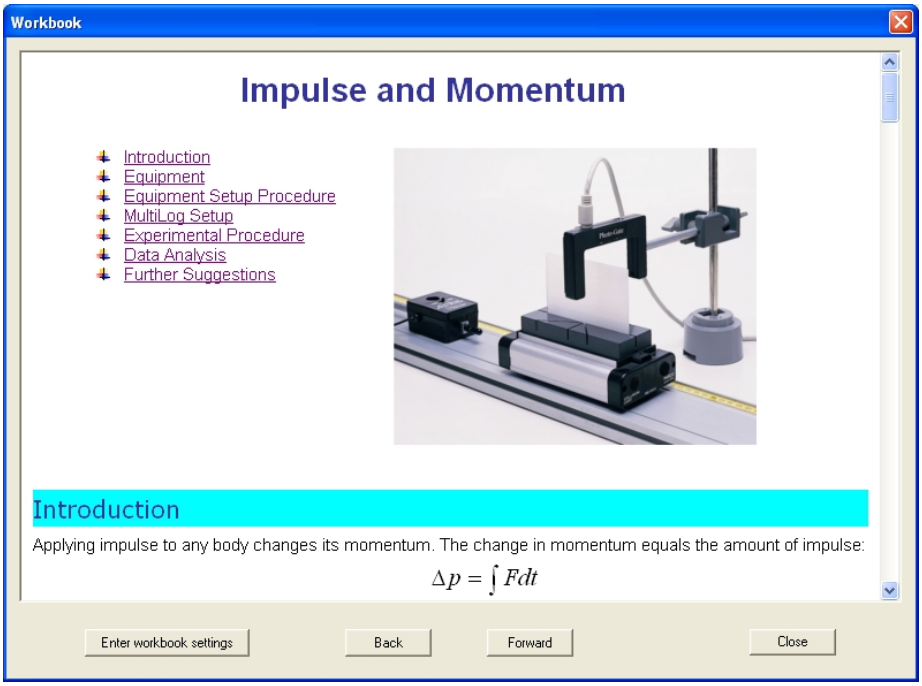


Figure 29: Creating a worksheet

4. Click **Enter experiment settings** to open the Setup wizard.
5. Use the Setup Wizard to preset MultiLab and data logger just as with the normal setup process (see page 64).
6. When you've finished entering the settings, click **Finish** to update the worksheet.
7. Click **OK**.
8. Click **Close**.

3.9. Special Tools

3.9.1. Predicting

The Predict tool enables you to draw predictions directly on the graph, prior to displaying the real data:

1. Click **Run** on the main toolbar to start recording.
2. Click **Pause/Continue** on the graph toolbar to freeze the graph.

   Data transmitted from the data logger while the graph is frozen, is stored onto the PC but is not displayed.
3. Click on the end of the curve and move the mouse according to your predictions. Click to draw a straight-line segment. Move the mouse again and click where you want the second segment to end, and so on.
4. Click **Add prediction** on the graph toolbar to create another prediction.
5. Click **Pause/Continue** a second time to resume live data display and to compare your predictions with the real data.

3.9.2. The Timing Wizard

1. Overview

The Timing Wizard enables you to easily measure and calculate many types of time events, including velocity and acceleration with one or two photogates.

Connect one photogate to input 1 or connect two photogates to input 1 and input 2 of the USBLink or MultiLogPRO and perform the experiment. The Timing Wizard will then guide you through the analysis.

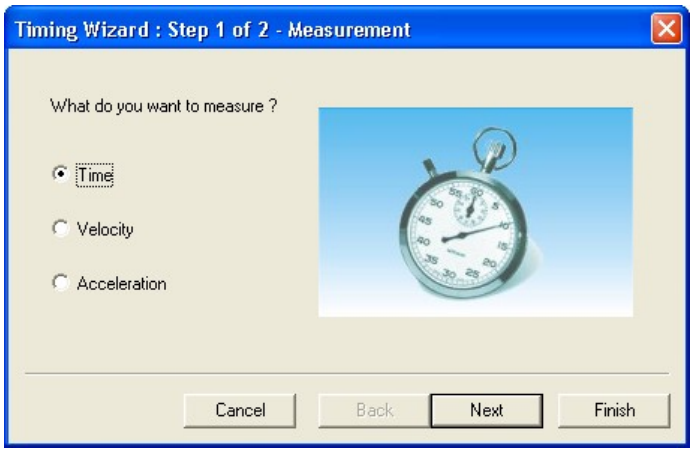
With the Timing Wizard you can measure sequences of time events at gate one and/or at gate two, or time events between the two gates. MultiLab can then calculate the velocity and acceleration. Special options make it easy to measure velocities in collisions and the time period of a pendulum or any other oscillating body.

The Timing Wizard can handle multiple events. For example, when a body is crossing a photogate several times, applying the Timing Wizard will result in a series of measurements that match the number of crossings.

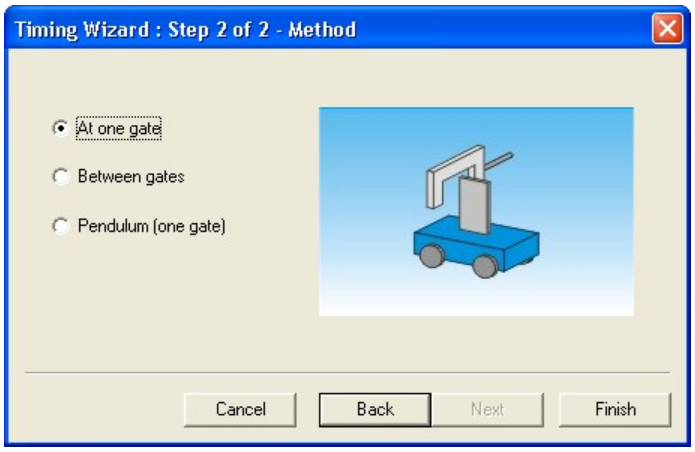
Note: If you wish to measure fast timing events with photogates only use MultiLogPRO's accurate timer module (see page 45).

2. Working with the Timing Wizard

1. Display the data that you wish to analyze in the graph window.
2. Click **Analysis** on the menu bar, then click **Timing Wizard** to open step 1 of the Timing Wizard dialog:



3. Click an option to select measurement: **Time**, **Velocity** or **Acceleration**.
4. Click **Next** to move to step 2:



5. Click an option to select the measuring method.
6. If required enter the body's width, or the distance between the gates in cm in the appropriate edit box (in velocity and acceleration measurements only).
7. Click **Finish** to display the results.
8. If you want to change the method or measurement, click **Back** to return to the Timing Wizard. To exit the Timing Wizard click **OK**.

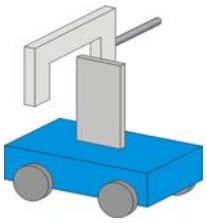
3. Measuring Methods

The Timing Wizard offers you various methods of analyzing the different measurements. In some measurements you will be asked to enter the dimension of the moving body, or the distance between the two photogates to allow for the calculation of velocity and acceleration.

The methods depend on the selected measurement:

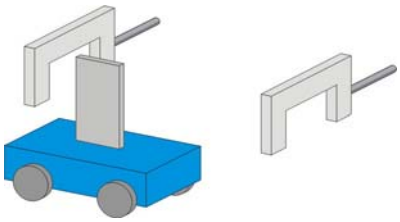
Time

- At one gate



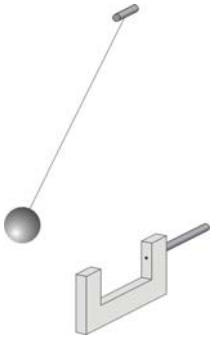
Measures the time it takes the body to cross the photogate (between blocking and unblocking the infrared beam).

- Between gates



Measures the time it takes the body to move from one photogate to the second photogate (between blocking the first and blocking the second infrared beams).

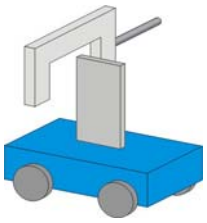
- Pendulum



Measures the time period of an oscillating body (the time interval between the first and the third blockings of the beam).

Velocity

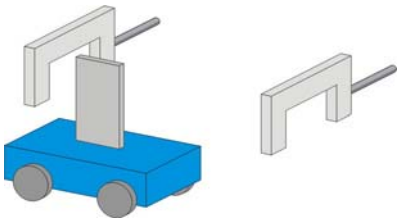
- At one gate



Measures the time it takes the body to cross the photogate (between blocking and unblocking the infrared beam) and returns the velocity.

You should enter the body's width.

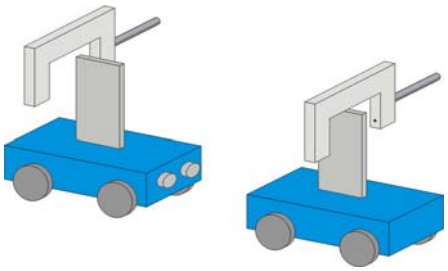
- Between gates



Measures the time it takes the body to move from one photogate to the second photogate (between blocking the first and blocking the second infrared beams) and returns the average velocity.

You should enter the distance between gates.

- Collisions

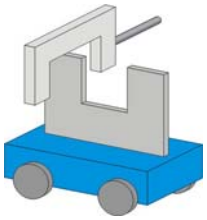


Measures the crossing time intervals at each gate and returns the corresponding velocities.

You should enter the bodies' width (the width of the two bodies must be identical)

Acceleration

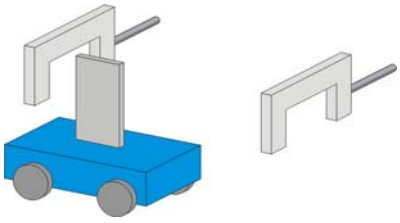
- At one gate



A card with two flags must be attached to the moving body (see figure to the left). The Timing Wizard measures the crossing time intervals of the two flags and returns the acceleration.

You should enter the flags width.

- Between gates



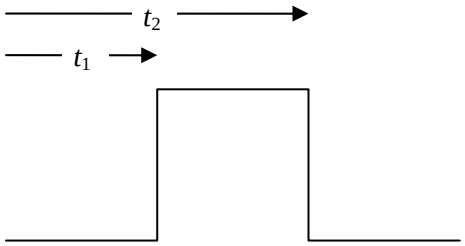
Measures the crossing time at the first gate, the time it takes the body to move from one gate to the second gate and the crossing time at the second gate and returns the average acceleration.

You should enter the body's width.

4. Time Schemes and Calculations

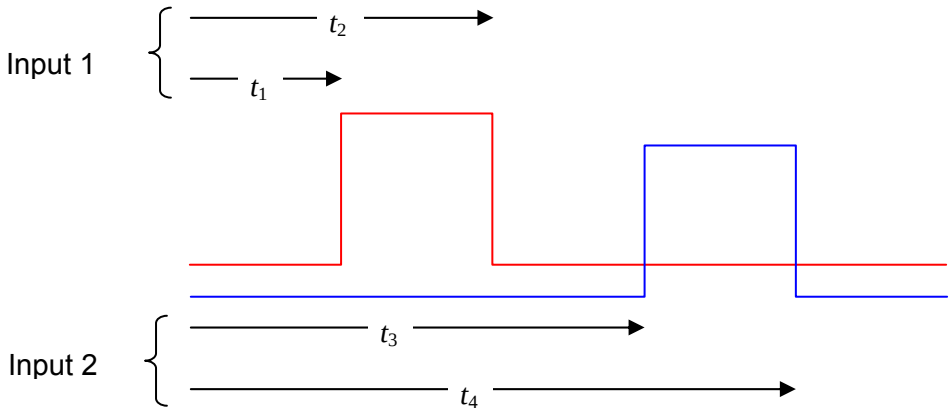
Time measurements

At one gate



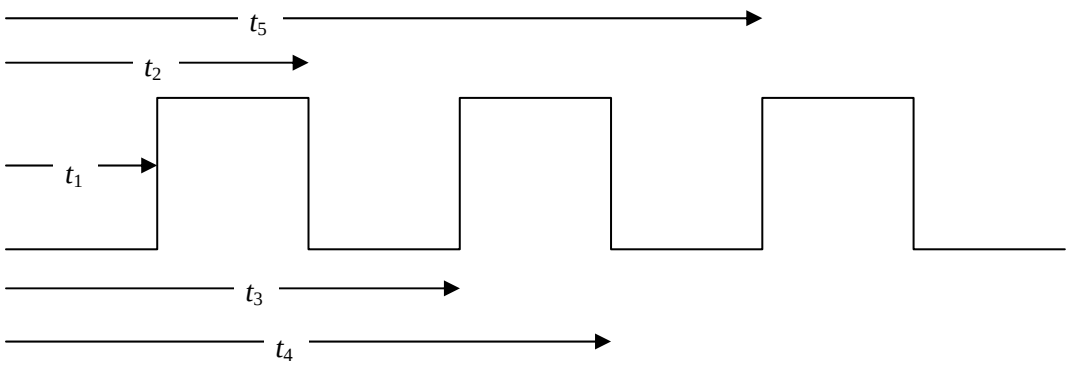
Result: $\Delta t = t_2 - t_1$

Between gates



Result: $\Delta t = t_3 - t_1$

Pendulum (one gate)

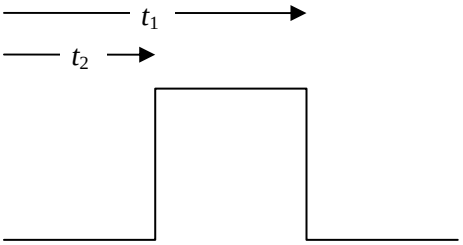


Result: $\Delta t = t_5 - t_1$

VELOCITY

At one gate

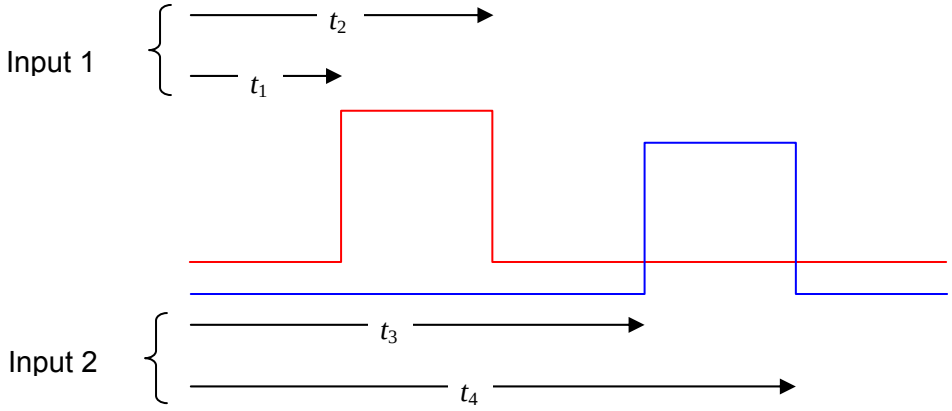
Required parameters: w – The body's width



Result: $v = \frac{w}{\Delta t}; \quad \Delta t = t_2 - t_1$

Between gates

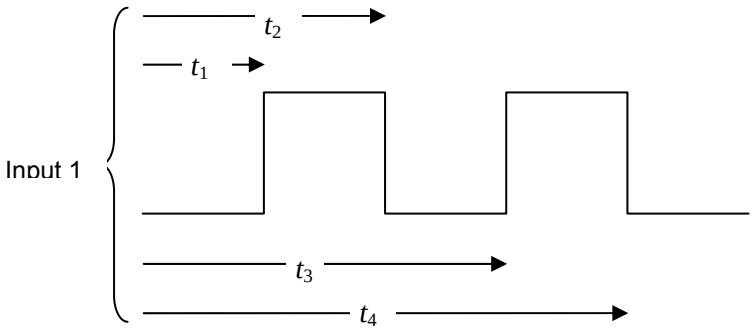
Required parameters: L – The distance between gates

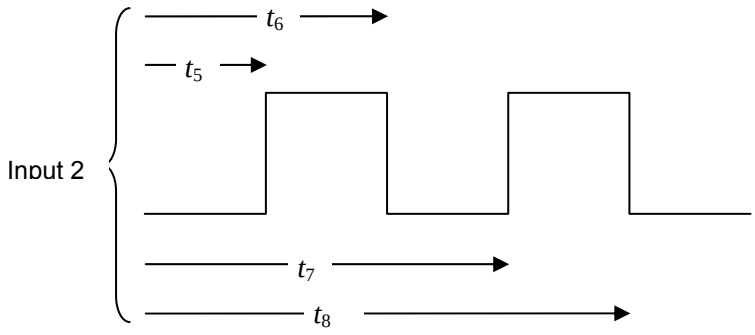


Result: $v = \frac{L}{\Delta t}; \quad \Delta t = t_3 - t_1$

Collision (two gates)

Required parameters: w – The bodies' width (must be identical)





Result:

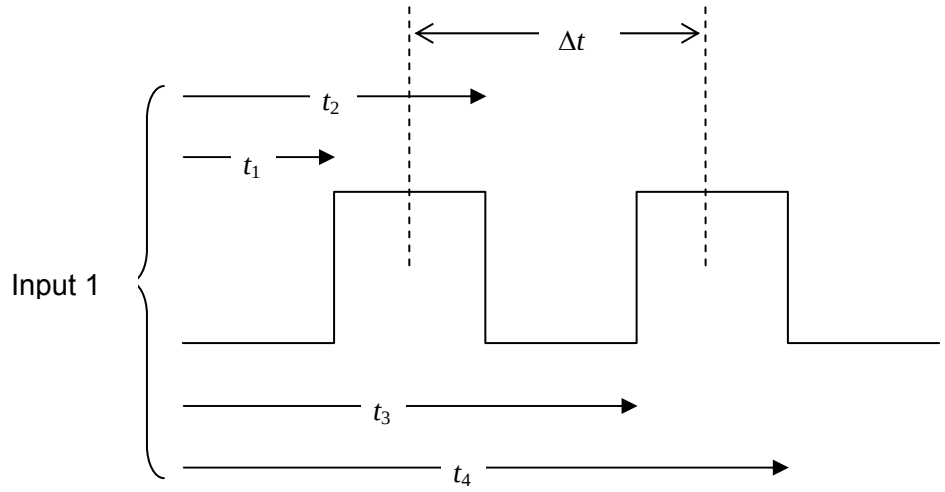
$$u_1 = \frac{w}{t_2 - t_1}; \quad v_1 = \frac{w}{t_4 - t_3}$$

$$u_2 = \frac{w}{t_6 - t_5}; \quad v_2 = \frac{w}{t_8 - t_7}$$

ACCELERATION

At one gate

Required parameters: w – The flags' width



$$v_1 = \frac{w}{t_2 - t_1}; \quad v_2 = \frac{w}{t_4 - t_3}$$

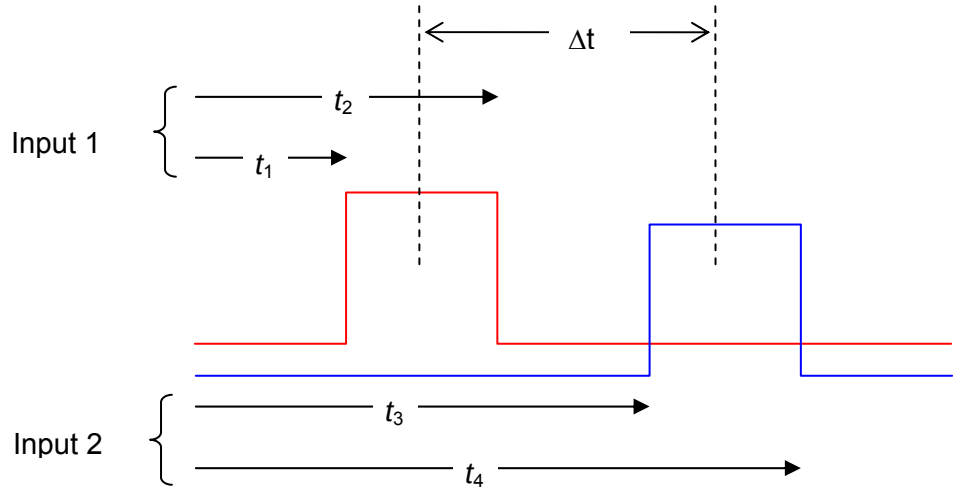
Result:

$$\Delta t = \frac{t_4 + t_3 - t_2 - t_1}{2}$$

$$a = \frac{v_2 - v_1}{\Delta t}$$

Between gates

Required parameters: w – The body's width



$$v_1 = \frac{w}{t_2 - t_1}; \quad v_2 = \frac{w}{t_4 - t_3}$$

Result:

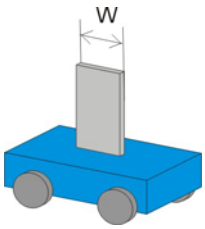
$$\Delta t = \frac{t_4 + t_3 - t_2 - t_1}{2}$$

$$a = \frac{v_2 - v_1}{\Delta t}$$

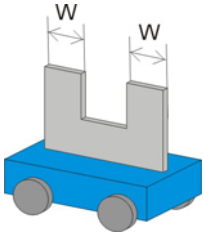
5. Tips on using the Timing Wizard

- **Attach a flag to the moving body**

When measuring the motion of a moving cart it is convenient to attach a vertical **flag** to the cart (see picture below). You can mount a slotted wooden block on the cart and insert the flag onto the slot, or use masking tape to attach the flag to one side of the cart.



Use a double flag to measure acceleration at one gate. The width of the two flags must be the same.



- **Use the cursors**

Use the cursors (see page 54) to select the graph and data range to which you want to apply the Timing Wizard.

- **Time resolution**

The time resolution depends on the sampling rate. Use the table below to select a rate that meats your needs.

Rate (samples per second)	Resolution
10	0.1 s
25	0.04 s
50	0.02 s
100	0.01 s
500	2 ms
1000	1 ms
2000	0.5 ms
10000	0.1 ms
20800	0.05 ms

- **Use the Trigger**

For fast events and high sampling rates use the Trigger tool (see page 68) to initiate the data logging.

3.9.3. Crop Tool

The Crop tool enables you to trim the edges of a data set. Use it to remove unwanted data or to apply manual curve fitting to a desired range of data points.

The time scale of the trimmed data is shifted so that it will start at $t = 0$.

If you want the automatic curve fit equation to start at $t = 0$, apply the crop tool before any type of curve fitting.

After applying the crop tool, the trimmed data set replaces the original set on the graph display and a new icon is added to the Data Map under cropped data.

1. To Trim all Data up to a Point

1. Position a cursor (see page 54) on the data point.
2. Click on the **Graph** menu, and then click **Crop**.

2. To Trim all Data Outside a Selected Range

1. Use the cursors to select the range you want to keep.
2. Click on the **Graph** menu and then click **Crop**.

3.9.4. Capture Tool

The Capture tool enables you to capture and record specific data points from the data logger's stream of data, like taking snapshots of the dynamic process. For example, you can design a light refraction experiment that will record the angle of the

refracted beam only when the light intensity is maximal, and then plot the angle of refraction vs. the manually entered column of the angle of the incident beam.

In capture mode, when you start recording, the data in the graph window appears as it normally does, but every time you click **Capture**, MultiLab enters the most recently recorded value into a new entry in the capture table.

When you have finished capturing data, you can add manual columns to the table and display the data in the graph window.

1. Preparing the Capture Table

1. Click **Table** on the menu toolbar, and then click **Capture mode** to open the Capture dialog box:

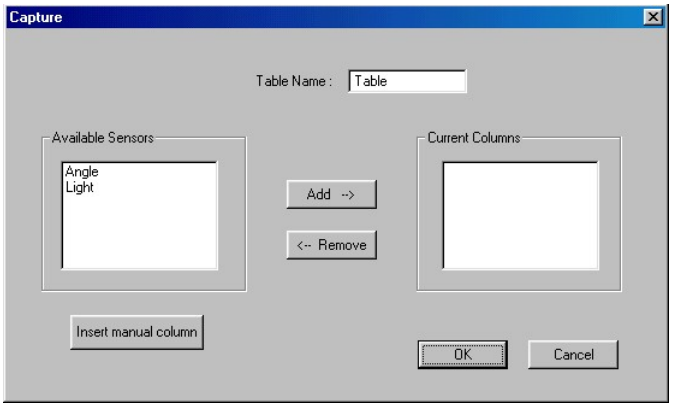


Figure 30: Capture dialog box

2. In the **Available Sensors** list, select the sensors you want to capture by clicking their name and then click **Add**.

3. If you want to insert a manual column into the table, click I**nsert manual column** to open the dialog box:

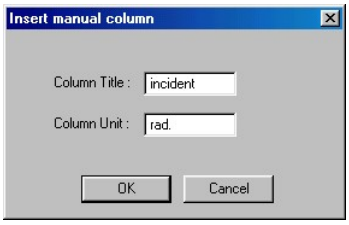


Figure 31: Manual Column dialog box

4. Enter the column's name and unit, then click **OK**.

The new column is added to the Current Columns list.

Note: You can always add manual columns later by clicking Add manual column on the Table menu.

5. Click **OK**.

   MultiLab opens a new table with the columns you defined.

6. Enter values into the manual column by clicking a cell and typing the number, then press **Enter** or the down arrow key to move to the next cell:

	Capture 1	Capture 1	
	incident (rad)	Angle (rad)	
	0		
	0.1		
	0.2		
	0.3		
	0.4		

Figure 32: Capture table

2. Capturing Data

1. Click **Run** on the main toolbar to start the data recording process.
2. Watch the online graph, and when the graph reaches a point you wish to capture, click **Capture** on the table toolbar. MultiLab enters the momentary data to the capture table sequentially.
3. If logging stops, simply click **Run** to continue the data recording and capturing.
4. After you've finished capturing the desired data, click **Table** on the menu toolbar, and then click **Capture mode** to exit capture mode.

3. Displaying the Captured Data on the Graph

1. Click **Edit graph** on the graph toolbar to open the **Graph edit** dialog box:

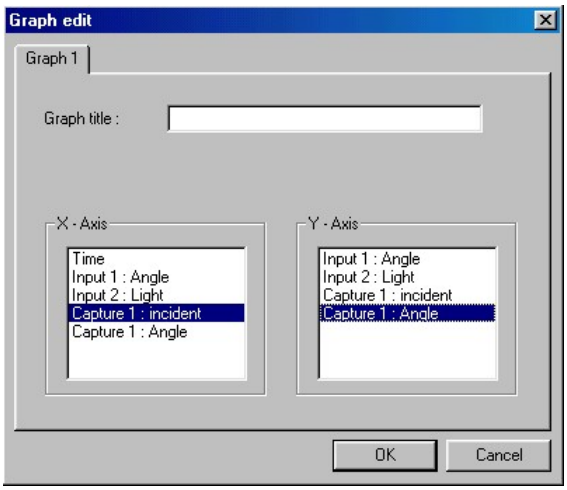


Figure 33: Using Graph edit dialog box to display captured data

2. Choose the data set that you wish to display on the X–axis from the **X–Axis** list by clicking its name.

3. Choose the data set or sets you wish to display on the Y–axis from the **Y–Axis** list by clicking its name (or names).

4. Click **OK**.

3.10. Toolbar Buttons

3.10.1. Main (Upper) Toolbar

	New	Start new project
	Open	Open saved project
	Save	Save project
	Print	Select print options
	Run	Start a data recording session. Click on the down arrow to select recording mode
	Stop	Stop recording
	Download	Download the data from the most recent recording session (for MultiLogPRO only)
	Setup	Open the Setup dialog box (for MultiLogPRO)
	Setup	Open the Setup dialog (for USBLink)
	Meter setup	Open the Meter setup dialog box
	Data map	Display the Data Map
	Graph	Display the graph window
	Table	Display the table window
	Video	Display and enable the video window
	Video Analysis	Open Video Motion Analyzer module

	Analysis	Open the Analysis wizard
	Linear fit	Draw a line of linear fit of the selected data set
	Derivative	Draw a line of the derivative of the selected curve
	Stop	Stop video recording or video replay
	Play	Replay video and/or data
	Pause	Pause replaying
	Record	Record video

3.10.2. Graph Toolbar

	Add annotation	Add new annotation to the graph
	Move annotation	Relocate the annotation on the graph
	Autoscale	Display all the data
	Zoom to selection	Zoom in to a selected area
	Pan	Pan in all directions while in zoom mode
	More smoothing	Smooth (average) the selected curve
	Less smoothing	Reverse the most recent smoothing operation
	1st Cursor	Display or remove the first cursor
	2nd Cursor	Display or remove the second cursor
	Split graph	Switch to a split graph display
	Edit graph	Select the data to display on the axes
	Graph properties	Graph formatting, scaling and units selection

	Add to project	Add the displayed graph to the project
	Export to Excel	Export the displayed graph to Excel
	Pause/Continue	Pause/continue displaying online data on the graph
	Add prediction	Add a prediction onto the graph
	Erase prediction	Erase the selected prediction

3.10.3. Table Toolbar

	Edit table	Add/remove columns from the table
	Table properties	Format fonts and units
	Add to project	Add the current table to the project
	Capture	Capture the momentary data

3.10.4. Video Motion Analyzer Toolbar

	Open	Open movie
	Capture	Capture new movie
	Set origin	Set the origin of reference frame
	Rotate axes	Set direction of reference frame
	Scale	Scale the data to real dimensions
	Delete point	Delete a point and point's coordinates
	Color settings	Select colors of markers and axes
	Go to start	Go to first frame
	Previous frame	Move to previous frame
	Play	Play the movie
	Next frame	Move to next frame
	Go to end	Go to last frame

3.10.5. Capture New Movie Toolbar

	Record	Start video capture
	Stop	Stop video capture
	Analyze movie	Return to Video Motion Analyzer mode

Chapter 4
Working with a TI Calculator

4.1. Overview

MultiLab for TI calculator is a data collection and analysis software that enables you to operate Fourier Systems MultiLogPRO data logger via TI–83 Plus. Together they constitute a portable, handheld, battery operated data collection system. The collected data can be than viewed and analyzed by the TI calculator.

4.2. Installing the Software

To send the MultiLab application to your TI–83 Plus calculator:

1. Connect the TI calculator to a computer.
2. Insert the MultiLab CD into your PC's CD-ROM drive. The MultiLab Installation application will launch.
3. From the main menu, click **Installing MultiLab Software**, then **MultiLab for TI83+ Installation**. In the next menu, click **MultiLab for TI83+ Installation** and the application file folder will open.
4. Run the TI Connect program on your computer.
5. Follow **Sending application to a TI–83 Plus** instructions.
6. When asked to select the application you want to install, select the multilab.8xk file located in the application folder launched from the MultiLab CD Installation wizard.

4.3. Getting Started

1. Prepare MultiLogPRO

1. Connect the stereo plug of the serial communication cable to the serial COM input on the bottom of the TI calculator.
2. Connect the 9 pins plug of the serial communication cable to the serial comm. socket on the left side of MultiLogPRO.
3. Turn on MultiLogPRO.
4. Configure MultiLogPRO to work with a TI calculator (see page 27).
5. Plug in any external sensors.

Note: MultiLogPRO must be in Auto ID mode (see page 27)

2. Run MultiLab on a TI Calculator

1. Turn on TI calculator.
2. Press APPS to see the complete list of applications that come with your calculator.
3. Use the down arrow button to navigate to MultiLab and press ENTER (or press MultiLab's number key).

   After showing the opening screen for a few seconds, MultiLab displays the main menu:

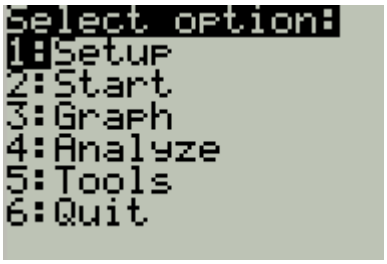


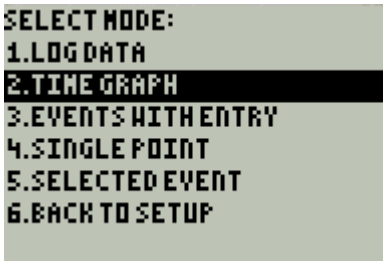
Figure 34: MultiLab for TI main menu

3. Setup MultiLogPRO

1. In the main menu screen press 1 to open the setup screen:

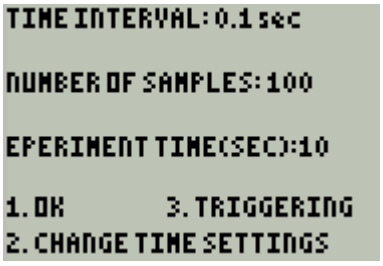
   MultiLab displays a list of the connected sensors and the current sampling mode.

2. Press 1 to return to the main menu or press ENTER to enter the sampling mode menu:



The default mode is TIME GRAPH that is the normal logging mode.

3. Press 2 to open the timing setup screen:



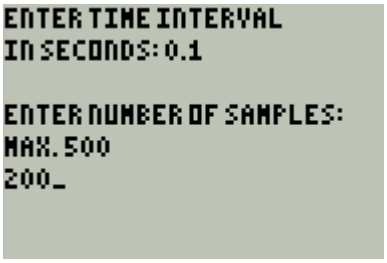
4. Press 1 to accept the settings and return to the setup screen or press 2 to change the settings:

5. Use the numeric keypad in the TI calculator to enter sampling time interval in seconds.

Tip: If you have entered a wrong value you can always press CLEAR and enter a new number.

6. Press ENTER

Note: The allowed time intervals are: 0.04, 0.1, 1, 10, 60, 600, 1800 and 3600 seconds. If you will enter another number MultiLab will automatically round it to the nearest allowed time interval.



7. Enter the total number of sampling point (maximum of 1000 samples unless otherwise indicated on the screen).

8. Press ENTER to return to the setup screen.

9. Press 1 to accept the setup and return to the main menu.

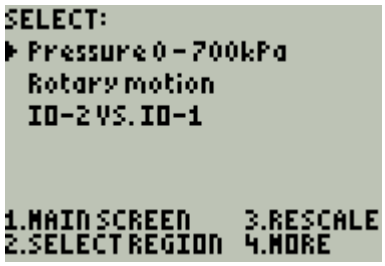
The system is now ready to begin data logging.

4. Start Recording

1. Press 2 in the main menu to begin data logging.

For time intervals of 1 second or more, MultiLab displays the data online. If the time interval is less than 1 second, data is retrieved by MultiLab after logging ends.

MultiLab than displays the SELECT GRAPH screen:



2. You can stop logging anytime by pressing STO.

5. View the Data

1. On the SELECT GRAPH screen use the Up and Down keys to select the graph you wish to display, then press ENTER.
2. To display another graph press ENTER, select a graph and press ENTER a second time.

Note: You can view the graph by pressing 3 from the main menu.

6. Downloading Data

To download data that is store in MultiLogPRO:

1. Press 5 on the main menu.
2. Press 1 on the Tools menu.
3. Enter the number of the experiment you wish to download.
4. MultiLab will retrieve the data and will display the SELECT GRAPH screen.
5. Use the Up and Down keys to select the graph you wish to display, then press ENTER.

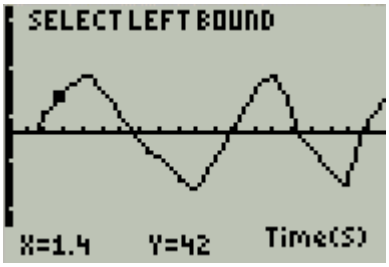
4.4. The Graph Display

1. The Cursor

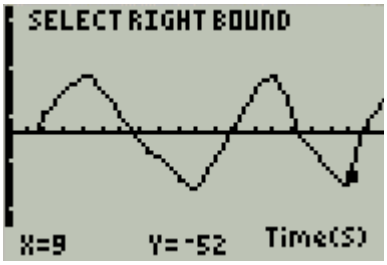
1. Use the cursor in the graph display to read data points values.
2. Press to display the cursor.
3. Press or to move the cursor through the graph points.
   The point coordinates are displayed at the bottom of the screen.

2. Zooming

1. From the graph screen press ENTER to return to the SELECT GRAPH menu.
2. Press 2 to select the region into which you wish to zoom in.



3. Press ▶ to select the left bound, keep pressing to move the left cursor to the desired point.
4. Press ENTER.

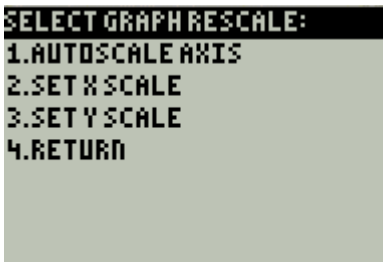


5. Press ◀ to select the right bound, keep pressing to move the left cursor to the desired point.
6. Press ENTER.
7. Use the Up ▲ and Down ▼ keys to select the graph you wish to display, then press ENTER.

Note: Data outside the zoom region will be trimmed and lost. To gain the data back download it from MultiLogPRO.

3. Rescaling

1. From the graph screen press ENTER to return to the SELECT GRAPH menu.
2. Use the Up ▲ and Down ▼ keys to select the graph you wish to rescale.
3. Press 3 to open the rescaling options menu.



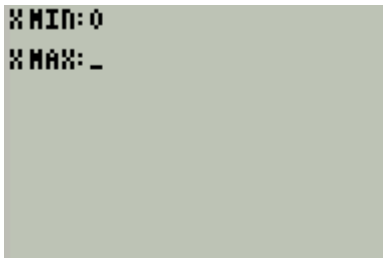
4. Auto Scaling

1. Press 1
2. Use the Up ▲ and Down ▼ keys to select the graph you wish to display, then press ENTER

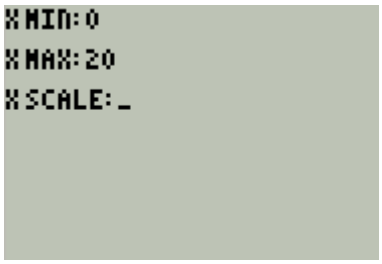
5. X – Axis Scaling

1. Press 2

2. Enter the minimum value, then press ENTER



3. Enter the maximum value, then press ENTER



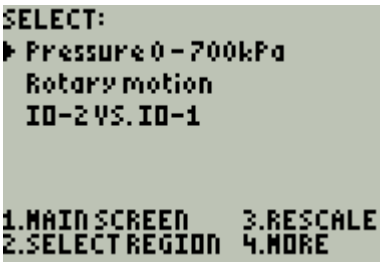
4. Enter the scale unit, then press ENTER
5. Use the Up and Down keys to select the graph you wish to display, then press ENTER

6. Y – Axis Scaling

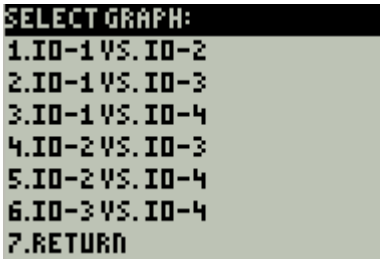
1. Press 3.
2. Enter the minimum value, and then press ENTER.
3. Enter the maximum value, and then press ENTER.
4. Enter the scale unit, and then press ENTER.
5. Use the Up and Down keys to select the graph you wish to display, and then press ENTER.

7. Choosing the X–axis

Normally MultiLab displays the sensors data as a function of the time, but you can choose to display a sensor's data on the x axis from the SELECT GRAPH screen.



1. One of the options in this menu is **IO-2 VS. IO-1**. If you select this option MultiLab will display the data from input 2 vs. the data from input 1.
2. For more options press 4.



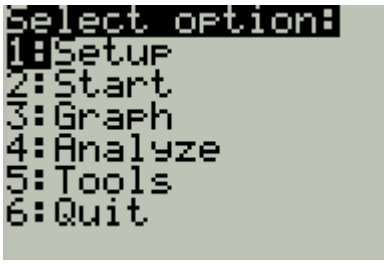
3. Use the Up and Down keys to select the desired option.
4. Press ENTER.

4.5. Analyzing the Data

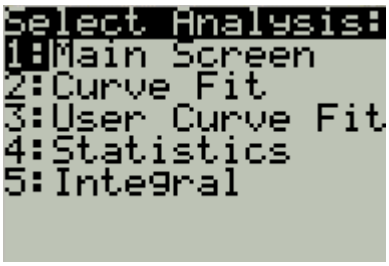
MultiLab offers you several types of analysis tools. You can apply built-in or user-defined curve fit to your data, you can integrate a data set to find the area or you can display a statistics screen.

1. Applying an Analysis Tool

1. Go the main menu.



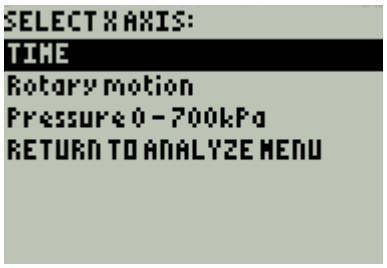
2. Press 4 to display the Select Analysis screen.



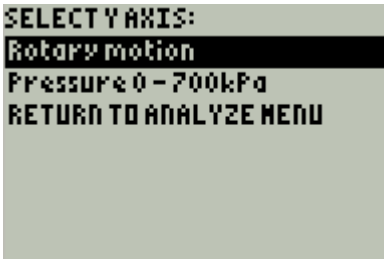
3. Use the Up and Down keys to select the desired option.
4. Press ENTER.

2. Curve Fit

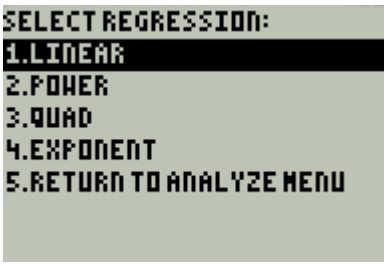
1. Press 2 from the Select Analysis screen.



2. Use the Up and Down keys to select the data for the X – axis, then press ENTER.

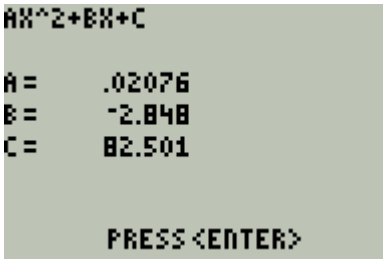


3. Use the Up and Down keys to select the data for the Y – axis, then press ENTER.



4. Use the Up and Down keys to select the fit type, then press ENTER.

MultiLab displays the fit formula:

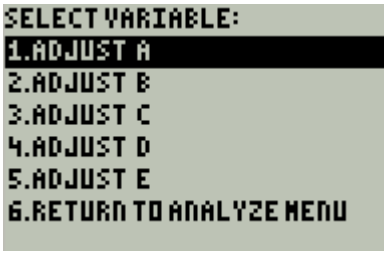


5. Press ENTER to display the curve fit on the graph screen.

3. User Curve Fit

This option allows you to create your own curve fit formula.

1. Enter your equation to the **Y=** editor of your TI calculator.
2. Run MultiLab and display the Select Analysis screen.
3. Press 3 from the Select Analysis screen.
4. Use the Up and Down keys to select a sensor, and then press ENTER.



5. Use the Up and Down keys to select a coefficient, and then press ENTER.
6. Enter a new value for that coefficient, then press ENTER.

   MultiLab calculates the new fit equation and displays it together with the analyzed data.

   You can repeat the process in order to change the coefficient value or to edit another coefficient.

4. Statistics

You can select a region of a data set and display statistics of the data range:

MINIMUM – The smallest value in the range

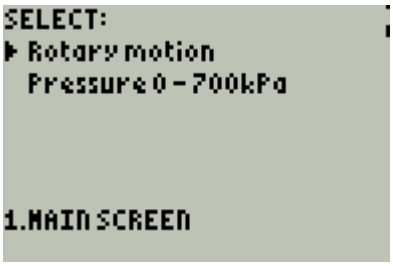
MAXIMUM – The largest value in the range

MEAN – The average of all the numbers in the range

STD. DEVIATION – The standard deviation

n – The number of data points in the range

1. Press 4 from the Select Analysis screen.



2. Use the Up and Down keys to select the sensor, and then press ENTER.

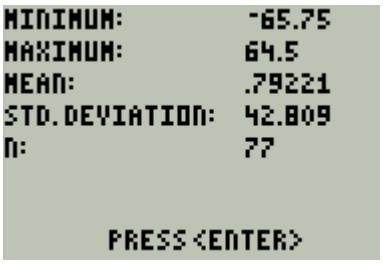
3. Press to select the left bound, keep pressing to move the left cursor to the desired point.

4. Press ENTER.

5. Press to select the right bound, keep pressing to move the left cursor to the desired point.

6. Press ENTER.

   MultiLab displays the statistics results screen:



7. Press ENTER to return to the main menu.

5. Integral

This option allows you to calculate the area of a selected range on the graph

1. Press 5 from the Select Analysis screen.

2. Use the Up and Down keys to select the sensor, and then press ENTER.

3. Press to select the left bound, keep pressing to move the left cursor to the desired point.

4. Press ENTER.

5. Press to select the right bound, keep pressing to move the left cursor to the desired point.

6. Press ENTER.

MultiLab displays the Integral results screen.

7. Press ENTER to return to the main menu.

4.6. Data Collection Modes

MultiLab offers you several types of data collection modes. The default mode is **TIME GRAPH** where data is collected in a predefined rate and then displayed on a graph as a function of the time.

The other data collection modes are:

LOG DATA – Downloading the last experiment from MultiLogPRO.

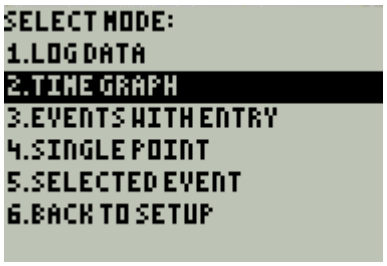
EVENTS WITH ENTRY – In this mode you can capture specific data points from MultiLogPRO stream of data, like taking snapshots of the dynamic process. After each capture MultiLab prompts you to enter a corresponding X value. When capturing ends, MultiLab displays the data vs. the manually entered X values.

SINGLE POINT – The system collects 10 samples in 10 seconds and then displays the average value.

SELECTED EVENT – Much like EVENTS WITH ENTRY except that the data is displayed as a function of the time (no need to enter X values).

To select a certain data mode:

1. Press 1 on the main menu to display the Setup menu then press ENTER to enter the **SELECT MODE** menu:



2. Use the Up and Down keys to select the collection mode, then press ENTER.

Working with the various collection modes:

1. Log Data

1. From the SELECT MODE menu select EVENTS WITH ENTRY, and then press ENTER.

2. Press 1 to return to the main menu.

3. Press 2 to start.

   MultiLab will retrieve the data from the last experiment store in MultiLogPRO.

2. Time Graph

This is the default data collection mode. See Getting Started on page 113 for details.

3. Events with Entry

1. From the SELECT MODE menu select EVENTS WITH ENTRY, and then press ENTER.
2. Press 1 to return to the main menu.
3. Press 2 to start recording.

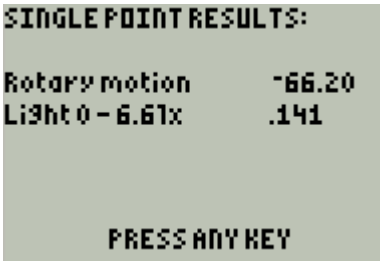
   MultiLab displays the sensors' values and the number of captured samples up to now.
4. Press ENTER anytime you want to capture a sample.

   MultiLab prompts you to enter a corresponding X value.
5. Enter the desired X value, and then press ENTER.
6. After you finish capturing the data press STO.
7. Use the Up and Down keys to select a sensor, then press ENTER to display a graph.

4. Single Point

1. From the SELECT MODE menu select EVENTS WITH ENTRY, and then press ENTER.
2. Press 1 to return to the main menu.
3. Press 2 to start recording.

   The system will collect data for 10 seconds, and then will display the averaged result:



Press any key to return to the main menu.

5. Selected Event

1. From the SELECT MODE menu select EVENTS WITH ENTRY, and then press ENTER.
2. Press 1 to return to the main menu.
3. Press 2 to start recording.

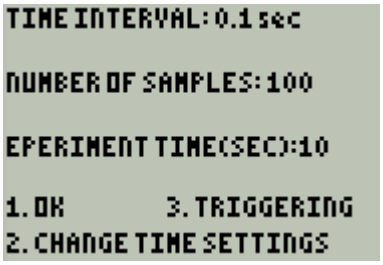
   MultiLab displays the sensors' values and the number of captured samples up to now.
4. Press ENTER anytime you want to capture a sample.
5. After you finish capturing the data press STO.
6. Use the Up and Down keys to select a sensor, then press ENTER to display a graph.

4.7. Conditioned Data Collection

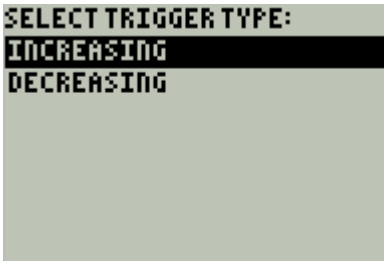
MultiLogPRO enables you to start the data collection only when a specific measurement condition has been met (triggering).

1. To Enable Triggering

1. Navigate to the timing setup screen (see Setup MultiLogPRO on page 114).



2. Press 3.
3. Use the Up and Down keys to select a sensor, then press ENTER to display the TRIGGER TYPE screen:



4. Select a trigger type:

   a) INCREASING – Data collection begins once the measured value is **HIGHER** than the threshold level.

b) DECREASING – Data collection begins once the measured value is **LOWER** than the threshold level.

5. Press ENTER.
6. Enter the triggering threshold level, and then press ENTER.
7. Press 1 to return to the main menu.
8. Press 2 to start.

   Data collection will begin once the triggering condition is has been met

2. To Disable the Triggering Condition

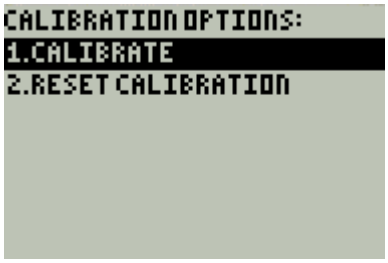
1. Navigate to the timing setup screen (see above)
2. Use the Up and Down keys to select **none**, then press ENTER.

4.8. Calibrating the Sensors

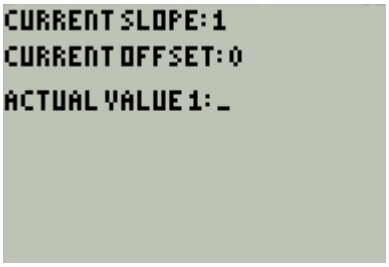
Every sensor has a unique conversion function that converts the sensor's output to the calibrated values. The two point calibration process sets the slope and offset (intercept) of the conversion function.

1. To Calibrate a Sensor

1. Connect MultiLogPRO to the TI calculator.
2. Press 1 from the main menu to display the setup screen.
3. Press 2, Use the Up and Down keys to select a sensor, then press ENTER to display the CALIBRATION OPTIONS screen.



4. Press 1 to begin calibrating.



MultiLab displays the current slope and offset. You should enter two actual values and the corresponding read values (the read values are

the values displayed by MultiLab when measuring the two actual values) .

5. Enter the 1st actual value, then press ENTER.
6. Enter the 1st read value, then press ENTER.
7. Repeat the last two steps for the other value.

   MultiLab will calculate the new slope and offset and will return to the setup screen.

2. To Restore the Default Calibration Values

1. Navigate to the CALIBRATION OPTIONS screen (see above).
2. Press 2.

   MultiLab will restore the default slope and offset and will return to the setup screen.

Chapter 5
Troubleshooting Guide

Symptom	*Cause of Problem*
I pressed the ON key on MultiLogPRO and it did not turn on.	• Try charging the battery, it may be weak. • You are using an unsuitable AC/DC adaptor (see page 14). • The internal 3V disk battery is dead.
MultiLab was unable to connect to MultiLogPRO.	• MultiLogPRO is turned off. • The communication cable is not connected properly. • The communication cable is not connected to the correct PC COM Port. • There is no available Serial COM Port. • The Logger USB driver was not installed.
MultiLab was unable to connect to USBLink.	• The USB communication cable is not connected properly. • The communication cable is not connected to the correct PC COM Port. • The USB driver is not installed
I downloaded *unexpected* data from the MultiLogPRO.	• There may be up to 100 experiments stored in the MultiLogPRO. Performing a Download means loading one of them in sequential order. You have probably loaded an old experiment accidentally. Try using **Selective download** from MultiLab (see page 44)
While running with an active trigger, MultiLogPRO does not complete the data logging.	• The trigger condition has not been fulfilled. • The trigger condition was fulfilled, but the time period was too short (less than 300μS).

I see voltage units when sampling using the microphone.	• The microphone is monitoring the sound wave shape, which is displayed in voltage units. The sound level, measured in decibel values, is another mathematical description of the sound amplitude.
I started a new logging session and the data logger stopped immediately afterwards.	First check if the sampling rate was so fast that the experiment began and ended in less than a second. If this is not the reason, recharge the 7.2 V battery of the MultiLogPRO and try again. MultiLogPRO monitors the battery power during the logging. If the battery voltage is less then 5V, the logging is stopped automatically.
The recorded data is *noisy*	• With voltage or current sensors, use short connections between the circuit being tested and the sensor. In some cases it is advisable to connect the (-) of the current sensor to the ground terminal • Avoid working near strong electromagnetic fields. (e.g. engines, fluorescent lights)
I turned the calibration screw but did not obtain the accurate calibration	The calibration screw is of high-resolution type and has 15 turns. Try to continue turning the screw, or change the direction of rotation.
I can't see a video of the experiment	• The video window is closed. Click **Display video** on the main toolbar to open it. • The video is disabled, select **Enable video** from the **Video** menu. • The camera driver is not properly installed.
I can't record voice comments	The microphone volume is muted. Open Window's **volume control** and uncheck the **Mute** check box at the bottom of the **Mic** volume column.
MultiLogPRO's memory is empty – there are no stored files or experiment notes.	The internal 3 V disk battery is dead. Replace the battery.

I opened MultiLab but the application immediately closed down.	During MultiLab installation, the component Windows Media Encoder (WME) is installed. Without WME, MultiLab cannot run. 1. In the **Control Panel**, open **Add or Remove Programs**. Check if WME is installed on your PC. 2. If WME is installed, check the WME version number. MultiLab v1.4.06 and higher supports up to WME Series 9. If you are running WME 9, make sure your MultiLab version is compatible. If not, contact your Fourier vendor for a MultiLab upgrade. 3. If WME is not installed then: a. Open Windows Explorer and right-click **Explore** on your CD drive. b. Locate the Windows Media Encoder installer file in the MultiLab folder and double click this file. c. Follow the on-screen instructions to install WME. You will now be able to run MultiLab. If you have WME 9 installed on a non-compatible version of MultiLab, you can always uninstall WME 9 and install WME 7 located on the MultiLab CD.
I opened MultiLab. An error message opened up stating that I needed Quicktime in order to run the MultiLab software.	Quicktime is a required component for MultiLab software to operate and is installed during initial MultiLab installation. If Quicktime has since been removed from your system, you may install it again from your MultiLab Installation CD: 1. Place the CD in your PC's CD drive and click **Cancel** to stop automatic MultiLab installation. 2. Open Windows Explorer and right-click **Explore** on your CD drive. 3. Locate the Quicktime installer file in the MultiLab folder and double click this file. 4. Follow the on-screen instructions to install Quicktime. You will now be able to run MultiLab.

Chapter 6
Specifications

6.1. The USBLink Data Logger

Input

4 Mini-Din sensor port interface

Auto ID mode:

Any combination of digital and analog inputs, with maximum of 4 digital inputs and 4 analog inputs

Automatic sensor identification across 4 inputs

8 inputs mode:

Any combination of digital and analog inputs, with maximum of 4 digital inputs and 8 analog inputs

Outputs

Mini USB (Type B) port, USB 1.1 (1.5 Mbit/s) specification compliant

4 Digital Control Outputs

Sampling

Analog sampling rate: From one sample per hour to 10,000 samples per second

Digital sampling rate: >200 kHz

Resolution

12-bit (4096 Levels)

Features

- Automatic or manual sensor identification
- LED indicators for power and logging status
- Saving and loading of last setup
- Trigger: programmable or manual
- Automatic calibration of offset sensors
- Screen contrast control
- Event recording
- Post experiment graphical analysis

Power Supply

Powered by PC USB port

Operating temperature range: 0 °C to 50 °C

Dimensions: 57 x 57 x 30 mm

Weight: 73 g

6.2. The MultiLogPRO Data Logger

Input

4 Mini-Din sensor port interface

Auto ID mode:

Any combination of digital and analog inputs, with maximum of 2 digital inputs and 4 analog inputs

Automatic sensor identification across 4 inputs

8 inputs mode:

Any combination of digital and analog inputs, with maximum of 2 digital inputs and 8 analog inputs

Outputs

RS-232 PC Host Interface at 19,200 bps

USB 1.1 specification compliant

4 Digital Control Outputs

Sampling

Capacity: Up to 100,000 Samples

Analog sampling rate: From one sample per hour to 20,800 samples per second

Digital sampling rate: >200 kHz

Resolution

12-bit (4096 Levels)

Timer Module

Time velocity and acceleration

Range: 0.0014 s to 6.5535 s

Resolution: 0.1 mS

Card width: 0 to 59 mm

Distance between gates: 0 to 99 cm

Stopwatch

Range: 0 to 99.99 s

Resolution: 10 mS

Man-machine Interface

- Full keypad operation enabling manual programming of the MultiLogPRO
- Graphic LCD
- Display uses: displaying the logger setup, displaying experiment instructions and notes and displaying the data measurements in graphs, meters, tables or digital display

Features

- Standalone operation - Working and sampling without connection to a PC.
- Automatic or manual sensor identification
- Saving and loading of last setup
- Automatic self-test that reports system status to the user including battery level in percentage of power remaining.
- Trigger: programmable or manual

- Automatic calibration of offset sensors
- Backup memory battery: 3V replaceable Lithium battery saving samples data for up to 10 years
- Automatic data recovery if there is a power failure
- Built in clock & calendar that keeps track of time and date for each data recording
- Built in battery charger for charging the 7.2V internal battery
- Automatic shut off after 15 minutes
- Screen contrast control
- Event recording
- 10 user defined sensors
- Online notes editing
- Post experiment graphical analysis

Power Supply

Internal rechargeable 7.2V NiCad battery or external 9V to 12V DC input

Battery life: 750 mAH, 24 hours between charges

Operating temperature range: 0 to 50 °C

Dimensions: 182 x 100 x 28 mm

Weight: 450 gr

Standards compliance: CE, FCC

6.3. Supported Sensors

This section lists all sensors compatible with the USBLink and MultiLogPRO. Together with the MultiLab software these sensors are used for data collection and data analysis.

For third-party sensors from Vernier and Data Harvest check availability with your local Fourier reseller.

6.3.1. Supported Fourier Systems Sensors

P/N	Type	Range	Physics	Biology	Chemistry
DT138	Acceleration	± 5g	✓		
AC020A	Ammonium Electrode	0.1 to 18,000 ppm		✓	✓
AC012A	Anemometer	Wind speed: 4 to 280 km/h Wind direction: 0 to 360		✓	
AC019A	Calcium Electrode	0.02 to 40,000 ppm		✓	✓
DT040	Carbon Dioxide (CO_2)	350 to 5,000 ppm		✓	✓
DT261A	Charge	± 0.25 uC to ± 0.025 uC	✓		
AC018A	Chloride Electrode	1.8 to 35,500 ppm		✓	✓
DT185A	Colorimeter	Three colors; blue, green, red		✓	✓
DT035A	Conductivity	0 to 20 mS	✓	✓	✓
DT110	Control Switch - Closed	Normally closed	✓	✓	✓
DT111	Control Switch - Open	Normally open	✓	✓	✓
DT005	Current 2.5 A	± 2.5 A	✓		✓
DT006	Current 250 mA	± 250 mA	✓		✓
DT020-1	Distance	0.2 to 10 m	✓	✓	
DT293	Drop Counter	0 to 4096		✓	✓
DT189A	EKG	0 to 5 V		✓	
DT254	Flow Rate	0 to 4 m/s		✓	
DT272	Force	± 10 N; ± 50 N	✓		
DT116	Geiger Muller	0 to 4096 Bq	✓	✓	✓
DT298A	Heart Rate (Exercise)	0 to 200 bpm		✓	
DT155A	Heart Rate (Pulse)	0 to 200 bpm		✓	
DT014	Humidity	0 - 100%, 5% accuracy	✓	✓	✓
DT009-1	Light	0 to 300 lux	✓	✓	✓
DT009-4	Light Triple-range	0-600, 0-6000, 0-150,000 lux	✓	✓	✓
DT156	Magnetic Field	0 to 10 mT, 0 to 0.2 mT	✓		
DT008	Microphone	± 2.5 V Frequency range:	✓		

P/N	Type	Range	Physics	Biology	Chemistry
		35 Hz to 10,000 Hz			
AC017A	Nitrate Electrode	0.1 to 14,000 ppm		✓	✓
DT222A	Oxygen Adapter	0 to 12.5 mg/L 0 to 25%		✓	✓
DT118	Oxygen Electrode	0 to 12.5 mg/L 0 to 25%	✓	✓	
DT017	pH Adapter	0 to 14 pH		✓	✓
DT018	pH Electrode	0 to 14 pH		✓	✓
DT137	Photo Gate	0 to 5 V (Digital)	✓	✓	
AC008A	Potassium Electrode	90 to 39,000 ppm		✓	✓
DT015	Pressure	150 to 1150 mbar	✓	✓	✓
DT015-1	Pressure	0 to 700 Kpa	✓	✓	✓
DT015-2	Pressure	0 to 10 Kpa	✓	✓	✓
AC013	Rain Collector	0 to 819 mm		✓	✓
DT148A	Rotary Motion	± 128°	✓	✓	
DT122A	Smart Pulley	0 - 99 m/s	✓		
DT171	Soil Moisture	0 to 200 cbar		✓	✓
DT320	Sound Level	45 to 110 dB	✓		
DT037A	Spirometer (Respiration)	± 315 L/min ± 5.25 L/sec			
DT025	Temperature (Thermocouple)	0 to 1200 °C	✓	✓	✓
DT027	Temperature (PT-100)	-20 °C to 400 °C	✓	✓	✓
DT029	Temperature	-25 °C to 110 °C	✓	✓	✓
DT095A	Turbidity	0 to 200 NTU		✓	✓
DT001	Voltage 25V	± 25 V	✓		✓
DT002	Voltage 2.5 V	± 2.5 V	✓		✓
DT003	Voltage 5 V	0 - 5 V	✓		✓
DT004A	Voltage 50 mV	± 50 mV	✓		✓
DT019	Voltage Triple Range	± 1 V, ± 10 V and ± 25 V.	✓		✓

6.3.2. Supported Vernier Sensors

Using an adapter available from Fourier Systems, the following Vernier sensors may be connected to the Fourier sensor interface. To use these sensors they must first be defined in MultiLab.

Note: Only Vernier Analog linear sensors are supported. Digital sensors are not compatible with Fourier data loggers.

Sensor	Units	Minimum Output Voltage	Minimum Real Value	Maximum Output Voltage	Maximum Real Value
Accelerometer 3 axis	m/s^2	0	-51.6	5	63.0
Accelerometer Low g	m/s^2	0	-51.8	5	62.9
Barometer Hg	Hg	0	24.2	5	35.7
Barometer atm	atm	0	0.8	5	1.2
Barometer mm Hg	mm Hg	0	614.8	5	907.4
Barometer mbar	mbar	0	819.5	5	1209.5
CO_2	ppm	0	0.0	5	10000.0
Colorimeter	%	0	0.0	5	142.9
Current $\pm$ 0.6A	A	0	0.625	5	-0.625
Differential Voltage	V	0	6.3	5	-6.3
Dissolved Oxygen	mg/L	0	-0.3	5	16.0
Dual Range Force 10N	N	0	12.3	5	-12.3
Dual Range Force 50N	N	0	61.3	5	-61.3
Flow Rate	m/s	0	0.0	5	5.0
Force 10N	N	0	12.25	5	-12.25
Force 50N	N	0	61.25	5	-61.25
Gas Pressure kPa	kPa	0	0.0	5	232.4
Gas Pressure atm	atm	0	0.0	5	2.2935
Gas Pressure mm Hg	mm Hg	0	0.0	5	1743.2
Light Sensor 0 - 600 Lux	lx	0	0.0	5	770.0
Light Sensor 0 – 6000 Lux	lx	0	0.0	5	8460.0
Light Sensor 0 – 150,000 Lux	lx	0	0.0	5	192120.0
Magnetic Field 6.4 mT in gauss	Low gauss	0	-80.6	5	80.6
Magnetic Field 0.3 mT in gauss	Hi gauss	0	-3.2	5	4.8
Magnetic Field 0.3 mT in millitesla	Low millitesla	0	-8.1	5	8.1
Magnetic Field 6.4 mT in millitesla	Hi millitesla	0	-0.3	5	0.5
Microphone	V	0	0	5	5
ORP	mV	0	-559.8	5	1774.6
Oxygen gas	%	0	0	5	32.8125
pH	pH	0.942	10.01	2.45	4.01

Sensor	Units	Minimum Output Voltage	Minimum Real Value	Maximum Output Voltage	Maximum Real Value
Relative Humidity	%	0	-23.8	5	140.7
Salinity	ppt	0	0.0	5	81.5
Thermocouple	C	0	-188.9	5	1393.0
UVA	mW	0	0.0	5	19700.0
UVB	mW	0	0.0	5	19700.0
Voltage ± 6 V	V	0	6.25	5	-6.25
X-Long Temp	C	0	-53.1	5	238.6
X-Long Temp	F	0	-63.5	5	461.5
Direct Connect	C	0	-17.8	5	260.0

6.3.3. Supported Data Harvest Sensors

Data Harvest sensors are able to connect directly to the Fourier sensor interface, without the need of any custom adapters.

To use the following Data Harvest sensors they must first be defined in MultiLab.

Note: Only Data Harvest Analog linear sensors are supported. Digital sensors are not compatible with Fourier data loggers.

Sensor	Slope	Intercept	Units	0 Volts (Min Output Voltage)	5 Volts (Max Output Voltage)	MultiLab Name
Current ± 100 mA	55.807	-139	m/s^2	-139	140.035	DH-100mA
Current ± 1 A	0.6233	-1.559	m/s^2	-1.559	1.55755	DH-1A
Current ± 10 A	5.547	-13.73	Hg	-13.73	14.005	DH-10A
Photogate 0-5 V	1	0	atm	0	5	DH-Photogate
pH 0-14 pH	4.3405	-3.982	mm Hg	-3.982	17.7205	DH-pH
Relative Humidity 0-100 %	-3.838	13.72	mbar	13.72	-5.47	DH-RH
Light 100 klux 0-100,000 lux	177.52	-87.515	ppm	-87.515	800.06	DH-Light-100K
Sound level 40 to 110dBA	118.56	-276.66	%	-276.66	316.14	DH-Sound

6.4. Accessories

Input Splitter DT011
Splits one I/O into two inputs
Enables simultaneous use of 8 inputs (analog or digital)

Sensor Cable DT022
Connects data logger to the sensors

Vernier Sensor Adaptor DT023
Enables the connection of all the VERNIER analog sensors (with DIN plugs) to the data logger

Serial Communication Cable DT135
Connects MultiLogPRO to a serial port on the PC

USB Communication Cable DT180
Connects MultiLogPRO to a USB port on the PC

Mini USB Communication Cable 12655
Connects USBLink to a USB port on the PC

Weather Box DT177
Sealed box, meets IP-65 standards
Used to store the MultiLogPRO while operating in rain or in dusty conditions

Solar cell AC029 (2 units needed)
Connects to MultiLogPRO's external DC input. Produces 12V @ 5W output power. Used for when MultiLogPRO is required to work for a long period of time in the field.

220V EUR AC/DC adapter DT245
Connects MultiLogPRO to European mains power

110V USA AC/DC adapter DT246
Connects MultiLogPRO to USA mains power

220V UK AC/DC adapter DT282
Connects MultiLogPRO to UK mains power

6.5. MultiLab Software (Windows and Mac OS)

- Windows support for USBLink and MultiLogPRO data loggers
- Mac support for MultiLogPRO
- Graph, video, table and meter displays
- True multimedia reports of your experiment with data, video, audio and text files
- Online or recorded video stream of the actual experiment
- Recording audio comments
- Automatic COM port recognition
- Online data transfer and display of data in real time
- Automatic and manual data download
- Stores data on disk files
- Quick export of samples data to EXCEL
- Import data from other applications
- Programs the data logger (instead of using the data logger keypad)
- Data Analysis:
    - Automatic curve fitting including Linear, polynomial, power and exponential
    - Integral
    - Derivative
    - Statistics
    - Smoothing (averaging)
    - Manual curve fitting
    - Mathematical and trigonometric functions
    - Timing wizard for easy analysis of timing events including velocity, acceleration, pendulum period and collisions
- Video Motion Analyzer
    - Capturing video movies
    - Capturing position and time
    - Analyzing with MultiLab's analysis tools
- Measurement readings facilitated by locating cursors on the graphic display
- Advanced zooming and panning tools
- Predict tool – Enables you to graphically predict results
- Capture tool – Enables you to capture and record specific data points from the stream of data downloaded from the data logger
- Crop tool – Enables you to trim the edges of a data set
- Workbook – Lab manuals with quick data logger setup programming
- Calibration of the data logger sensors
- Capability of interfacing with sensors from other vendors

6.6. MultiLab Software (TI-83 PLUS Calculator)

- Graphic display
- Online data transfer and display of data in real-time
- Automatic and manual data download
- Programs the data logger (instead of using the data logger keypad)
- Triggering
- Data Analysis:
    - Automatic curve fitting: linear, quadratic, power and exponential
    - Integral
    - Statistics
    - User curve fitting
- Measurement readings facilitated by locating cursors on the graphic display
- Zoom tool
- Calibration of the data logger sensors

Appendix A: Figures

Figure 1: USBLink external connections 4
Figure 2: Frequency Aliasing 8
Figure 3: Contents of the MultiLogPRO system 12
Figure 4: MultiLogPRO external connections 13
Figure 5: MultiLogPRO front panel 15
Figure 6: Frequency Aliasing 29
Figure 7: MultiLab window layout 40
Figure 8: Video properties dialog box 44
Figure 9: View selection dialog box 53
Figure 10: Edit graph dialog box 56
Figure 11: Edit table dialog box 59
Figure 12: Setup wizard step 1 of 3 64
Figure 13: Setup wizard step 2 of 3 64
Figure 14: Setup wizard step 3 of 3 65
Figure 15: X-axis properties dialog box 68
Figure 16: Triggering dialog box 68
Figure 17: Edit experiment notes dialog box 70
Figure 18: Define new sensor dialog box 72
Figure 19: Communication setup dialog box (Windows) 73
Figure 20: Communication setup dialog box (Mac OS) 73
Figure 21: Analysis wizard – curve fit 76
Figure 22: Analysis wizard – averaging 77
Figure 23: Analysis wizard – functions 78
Figure 24: Analysis Wizard – online functions 83
Figure 25: Using graph edit dialog to display online functions 84
Figure 26: Online envelope function 84
Figure 27: Manual curve fit toolbox 85
Figure 28: Worksheet 95
Figure 29: Creating a worksheet 97
Figure 30: Capture dialog box 107
Figure 31: Manual Column dialog box 107
Figure 32: Capture table 108
Figure 33: Using Graph edit dialog box to display captured data 108
Figure 34: MultiLab for TI main menu 114
Figure 35: I/O socket configuration. 142

Appendix B: Adding a Code Resistor to a Custom Sensor

In order for the data logger to automatically identify a sensor, it must have a code resistor. Figure 35 shows the input socket configuration for the USBLink and MultiLogPRO.

You must connect the resistor between the Auto recognition resistance input and the GND input.

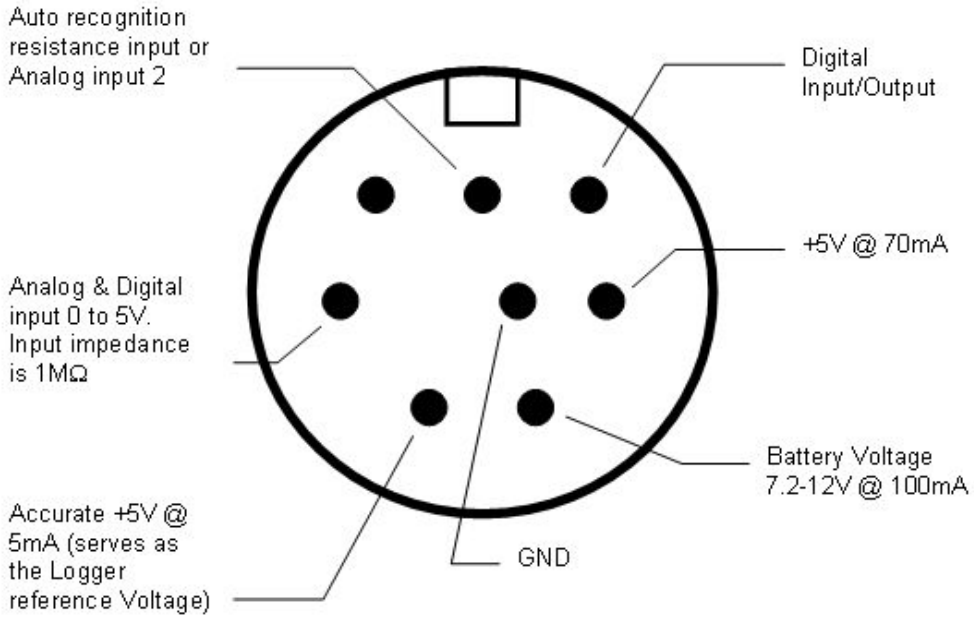

Auto recognition resistance input or Analog input 2
Digital Input/Output
+5V @ 70mA
Analog & Digital input 0 to 5V. Input impedance is 1MΩ
Battery Voltage 7.2-12V @ 100mA
Accurate +5V @ 5mA (serves as the Logger reference Voltage)
GND

Figure 35: I/O socket configuration.

Mini DIN female. Data logger panel view.

When you define a custom sensor in the MultiLab program you must choose one sensor from the list provided. Note its position in the list and look in Table 1 to find the resistance.

Table 1: Auto recognition resistors

Position in *Define sensor* dialog box drop down menu	**Resistance** (kΩ)	**Max Resistance** (kΩ)	**Min Resistance** (kΩ)
1	372	384.1	360.9
2	410	424.8	396.5
3	455	472.9	437.8
4	508	530.9	486.6
5	573	601.9	544.8
6	653	691.1	615.6
7	754	806.5	703.4
8	888	961.9	814.6
9	1071	1183.0	959.2
10	1337	1524.4	1151.2

Index

A

acceleration · 98
adaptor · 14, 138
analysis · 74, 119
  averaging · 77
  carve fit · 76, 120
  derivative · 75
  function · 78
  integral · 76
  manual curve fit · 85
  online · 83
  smoothing · 74
  time events · 98
  wizard · 76
area · 122
automatic identification · 6, 16
autoscale · 55
averaging · 77

B

battery · 14

C

cable · 5, 6, 12, 13, 16, 138
calculator · 113
calibration · 10, 11, 28, 32, 33, 71, 126
capture · 106, 123
clear
  data · 62
  memory · 70
  online function · 85
code resistor · 71, 142
COM port · 72
communication setup · 72
configuration · 27
connect · 73
continuous · 8, 9, 30, 31
contrast · 28
control · 69
coordinates · 22, 54
copy · 63
crop · 106, 116
cursor · 22, 54, 116
curve fit · 75, 76

D

data map · 61
delayed start · *See* triggering
delete · 62
derivative · 75
display
  control the display · 61
  data map · 61
  graph · 53
  meters · 61
  options · 53
  properties · 67
  select · 18
  table · 59
  video · 43
Do2 · 28
download · 44, 45, 116

E

edit
  data values · 59
  graph · 56
  notes · 70
  table · 59
enter · 17, 19
escape · 20
event recording · 69
Excel · 63
experiment notes · 70
export · 63
external DC power · 14

F

format
  graph · 57
  table · 60
functions · 78, 79

G

gain · 10, 32
getting started · 41
graph · 22, 53

H

hardware calibration · 10, 32

I

icon · 20
import · 50
input · 5, 13
input mode · 27
integral · 76

K

keypad · 15

L

layout · 15
load
  experiment notes · 70
  last setup · 27

M

manual
  curve fit · 85
  sampling · 8, 30, 43
  table column · 107
measurement · 65
memory · 30
  clear · 28, 70
menu · 19
meter · 20, 61

N

notes · *See* experiment notes
number
  graph · 57
  of samples · 18, 20, 65
  table · 60

O

offset · 10, 32
online
  analysis · 83

communication · 45
video · 43
open · 50

P

panel · 15
panning · 56
pH sensor · 11, 33
port · 14
predict · 98
preset · 67
print · 51
programming
MultiLog Pro · 64
rules · 9, 30
USBLink · 64
project · 41, 50
properties
graph · 55, 57
sensor · 65
table · 60
video · 44

R

rate · 7, 9, 17, 20, 29, 31, 45, 65, 129, 131, 132
recording
data · 18, 42
options · 42
rate · *See* rate
start · 70
stop · 70
time · 18, 20, 65
video · 43
regression · *See* curve fit
replay · 43
requirements · 34
run · 42, 43, 70

S

sampling Points · 8, 30
sampling rate · ***See* rate,** See rate
save · 50
scale · 55
screen contrast · 28
scroll · 65
sense & control · 69
sensor · 5, 13, 17
assign to input · 64
Auto ID · 6, 16, 27
calibration · 10, 32, 71
custom · 71
measurement · 65
plug in · 17
properties · 65
setup · 7, 17, 20, 26, 27, 29, 64, 114
slope · *See* derivative
smoothing · 74
snapshot · 106
socket configuration · 142
spreadsheet · 63
stand alone · 15
start · 18, 20, 42
statistics · 121
stop · 18, 20, 42
system configuration · 27

T

table · 20, 59
temperature
compensation · 11, 33
TI · *See* calculator
time events · 98
timer delay · 69
timing · 98
toolbar
graph · 110
main · 109
table · 111
triggering · 68, 125
trim · *See* crop
troubleshooting · 128

U

units
graph · 57
table · 60
USBLink · 1
layout · 4

V

value · 22, 54
velocity · 98
video · 43
view · 53
voice comments · 43

W

wizard
timing · 98
workbook · 95
worksheet · 95
creating · 96
opening · 95

X

X-axis · 57, 67

Y

Y-axis · 53, 56

Z

zoom · 22, 55